METALLURGIA

THE BRITISH JOURNAL OF METALS.

JUNE, 1931. VOL. IV. No. 20.

Modern Steel-Pouring Plant

Some Characteristic Plant Layouts

By K. R. Binks.

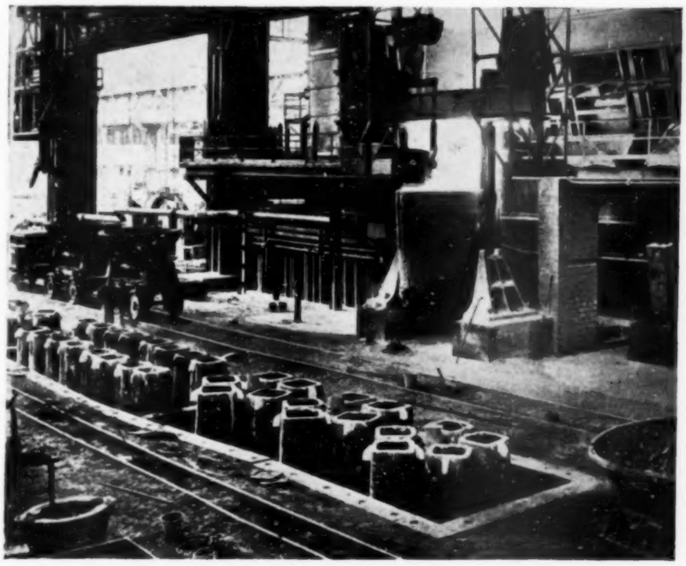


Fig. 1.—Illustrates a complete plant installed by the Demag Company of Duisburg according to the latest principles for the Ruhrurt-Meiderich works of the Vereinigte Steelworks combine. The 12 ton guided stripper crane shown in the background travels at a speed of 295 feet per minute, handling all moulds and ingots.

THE equipment of the steel-pouring shop must be of the type most suited to the nature of the products it is intended should be made. While this is one of the first principles of design for the economical handling of materials and apparatus, it is not always carried out, excepting only the most recently constructed plants, with consequent loss of valuable time, extra labour costs, and interruption in the smooth passage of material from the furnaces to the rolling mills. It will be apparent that the casting bay most suited to the economical production of ingots for the rolling of heavy plates would not be efficient in the smooth handling of the large quantity of moulds, refractory heads, and bottom pouring equipment associated with the casting of small ingots either for seamless tube making or for direct rolling to small sections. Each type, therefore, has a characteristic number and design of cranes for the quick assemblage of equipment.

There are three main lifting operations in the ingot casting bay. The most prominent is the transfer of the full casting ladle from the furnace to various points in the shop, the second is that of the almost continuous handling of light loads in preparation for the next heat of steel, and the third, the transference of the ingots to the site of the next stage in manufacture, the rolling mills.

Casting ladles are almost universally carried in overhead track cranes of high lifting power, several of which are shown in the illustrations, but there are in certain cases electrically propelled ladle carriages installed for the transference of the casting operations to other bays, and, in older works, ladle carriages running over straight pits. The number of cranes to be installed for the teeming of the heats depends greatly on the size of the shop. One crane for the product of two furnaces is not prohibitive in capital cost where the number of furnaces does not exceed six, but where there are as many as ten or twelve, economy demands that the crane should be released for the further transference of ladles from other furnaces by placing the full ladles in appropriate teeming stands. The overhead casting cranes are invariably fitted with auxiliary trolleys in the cross beams for the performance of lighter duties, such as the overturning of the ladle after teeming the ingots, and the handling of materials for the many casual duties in the shop. Such cranes are not suited to the rapid and continuous handling of numerous light articles over long travelling distances, and they necessitate a proper complement of light-structure quick-handling cranes for this purpose. These may be conveniently carried on a superimposed track where pit-casting methods are in use, but where ingots and moulds are novable on bogies to separate buildings attain the maximum of efficiency in unrestricted movements in a shop with adequate storage and ingot and mould preparation facilities. They may also under these conditions be of the guided mechanical grip or of the power stripper type, thus minimising the number of small delays associated with loose chains depending from unguided wire ropes.

The movement of ingots after stripping off the mould is a comparatively easy operation, where bogie teeming is installed, since they may be shunted immediately to the reheating furnaces. Where, however, the ingots are in casting pits or on the ground level, they necessitate an extra lift by the crane by which they are placed either on trucks, on ingot turntables, or within reach of jibbing motion cranes installed in the adjacent soaking furnace bay.

Under efficient conditions, therefore, heavy lifts, such as full or empty casting ladles, slag ladles, heavy tun-dish casting ladles, and ladles of liquid pig iron for pouring into the furnaces, are handled in the button hooks of the casting crane, and are kept as much as possible in the immediate vicinity of the furnace. Other and lighter or more numerous loads, such as those of the moulds, ingots, and refractory heads are transported, either by bogies or

by slewing-motion jib cranes, into the appropriate crane bay or a convenient part of the pouring shop by the light overhead track cranes.

Broadly, open-hearth plants fall into three categories. The first of these, and a development in the modern high output repetition of one class of product, is that of the plant producing heavy individual tonnages, either of plate and

Fig. 2.—250-ton charges at 13 to 15 hour intervals are divided by means of the tilting furnace into three ladles held by the cranes during tapping. The moulds are kept stationary.

structural sections or tin-plate bar. Under these conditions the open-hearth units consist of :—

(*a*) A small number of large size continuous hot-metal process tilting furnaces, producing moderate quantities of steel at short intervals.

(*b*) A greater number of large size fixed or tilting open-hearth furnaces tapping relatively large amounts of steel at intervals of from 10 to 15 hours, as practised in many American plants.

(*c*) Or by a number of fixed furnaces producing heats at exceptional rates of from 6 to 7 hours, a characteristic German procedure.

The short intervals between the tapping of heats in the plants of (*a*) and (*c*) types necessitates the quick removal of the ingots, moulds, and accessories away from the site of the casting operations and their easy replacement by apparatus prepared for the succeeding casts. The carrying of moulds upon bogies satisfies these conditions, but the

Fig. 4.—A Welsh plant of 60-ton basic open-hearth furnaces served by a guided "tong crane" in addition to the Wellman ladle crane.

limitations of the method make top casting almost a necessity, since the number of lifting operations by the cranes is at a minimum with such a procedure. Small ingots, however, of from 10 cwt. to 20 cwt. for direct rolling to finished products cannot be produced free from surface blemishes when using top pouring methods from ladles of large capacity, since the small nozzle employed prolongs the time that the metal is kept in the ladle, with consequent tendency to chilling. Casting in clusters, therefore, becomes a preferable method by which a large output of this character may be attained, and extra crane power is arranged for accordingly.

Fig. 1 illustrates one of the latest continental installations, and shows the tapping of a heat and subsequent teeming into both cluster and top-poured moulds. The weight of metal tapped into the ladle is approximately 65 tons at four to five intervals, liquid ferro-manganese being poured ffinto the ladle while tapping. A further development of the same principle is afforded by the arrangement of an additional multi-nozzled ladle for the reception of steel from the main ladle, and its subsequent re-pouring into several moulds simultaneously. The moulds are conveniently carried on the usual bogies, the main ladle is kept stationary, the auxiliary ladle being placed in a teeming stand capable of adjustment in several directions for accurate "spotting" over the moulds.

Fig. 3.—A complete Wellman installation of open-hearth acid and basic furnaces having a nominal throughput of 1,400 tons per 24 hours. Gas-fired ladle dryer is shown on the right with detachable power-driven mould stripper in the background.

The tapping of larger heats at longer intervals as practiced in the majority of American plants allows greater time for the preparation of moulds for the succeeding heats, but the heavy tonnages in each ladle bring, in themselves, a more difficult problem of the increased strength required in lifting equipment and the structure of the shop. Casting cranes have to be built to accommodate loads of from one to three hundred tons, and, moreover, to move these loads smoothly for very small distances during the teeming of the metal. A difficult engineering problem is thus presented which may be solved to some extent by the distribution of the contents of the furnace into two or three ladles by means of the tilting furnace or the divided launder or tapping trough. The crane, too, is then kept stationary, the mould bogies moving hydraulically during centring under the ladle. Such an arrangement is illustrated in Fig. 2, where three ladles of metal are tapped consecutively from one heat of the tilting furnaces, the Wellman crane illustrated being of

125 tons capacity. Details of four 100-ton casting cranes are shown in Fig. 3, where a battery of fixed 75-ton open-hearth furnaces are served by these cranes for both the casting operation and the previous handling of the moulds, etc. Each crane travels only a short distance : steel and slag ladles, moulds, and auxiliaries are kept immediately in front of the furnace. Longer travelling manipulations are performed by the steelworks locomotives, moving the appropriate bogies.

In the second category are those plants producing steels solely to high-carbon or alloyed specifications, and in the third, those plants which aim at the production of steel to meet any specification, and in all sections and sizes, from the one melting plant.

For the first of these types high output capabilities are not required, but rather great flexibility in dealing with many types and sizes of mould. For example, moulds for the casting of ingots for forgings will accommodate ingots of from 2 to as much as 60 or 70 tons, their cross-section often approaching that of the circular. On the other hand, alloyed steels for the rolling mills will require an ingot of from 15 cwt. to 40 cwt., with a cross-section tending towards that of the square. Obviously, mass-production methods cannot be used, mould bogies and mechanical grips on the cranes being of no value. The carrying of the ladle in an overhead casting crane allows of the "spotting" at any point in the shop and at various heights of the ladle over the mould, and the use of a large size rectangular casting pit, adjacent to each furnace, brings the work within easy reach of the men. Light cranes for the handling of miscellaneous equipment are most conveniently placed on superimposed crane tracks, where they may move independently of the casting cranes.

In the third category provision has to be made to satisfy any type of casting operation. Such a plant is illustrated in Fig. 4, where bogie teeming, pit casting, and the setting of moulds at ground level is illustrated. Manipulation of the moulds is carried out by a Wellman guided-tong-type crane, which also strips and loads into trucks all ingots not handled by the ingot bogies. The ladle crane shown carries the ladle during teeming, and also pours into the furnace the charge of liquid pig iron.

A gas-fired ladle dryer designed by Wellmans showing also shield for the diminution of radiation and control of the flame.

Special Tramway Trackwork.

THE accompanying illustration shows an interesting example of special trackwork supplied for tramways, which is of an outstanding character. The work has been constructed for the new Swinegate Depot of the Leeds Corporation Tramways, and comprises a new car fan with 15 turnouts. The layout is of Edgar Allen Company's Imperial manganese steel from the toe of the first point to the end of the rails on all the curves.

The outer rails of curves are of B.S.8c section with special $1\frac{1}{2}$ in. wide grooves, and are cast solid in manganese steel. The inner rails of the curves are also cast solid of manganese steel, but without check, so that the Holt's rolled manganese steel guard rails can be fitted. The exigencies of the site required a sharp radius of 30 ft. $1\frac{1}{2}$ in. for the main curves, which necessitated the increasing of the width of the grooves to $1\frac{1}{2}$ in. on all curves. Easement curves were employed off the main track to give sweet running for the cars.

Car Fan with Turnouts.

Fifteen turnouts comprise 15 pairs of movable and open points, and 10 of the open points are combined with crossings forming compound castings. The heaviest crossing is 12 cwt., and the heaviest point is also 12 cwt., the total weight of manganese steel in the complete job being 46 tons. The overall length of the layout is 200 ft., while the total length of manganese steel rail in the fan is 1,415 ft., with over 600 ft. of Holt's rolled manganese steel guard rail. All the movable points are of the Bighead type, fitted with the Acme heel adjusters, which are now extensively used in this country.

The whole contract, which was executed by Messrs. Edgar Allen and Co., Ltd., of Sheffield, within three months of the placing of the order, in its entirety, forms a car shed unique in tramway engineering.

Messrs. Vickers-Armstrong of Newcastle on Tyne, have secured an important contract for alterations to the Blue Star Liners ARANDORA and ANDALUCIA. The work will involve extensive reconstruction and the expenditure is reported to be about £200,000.

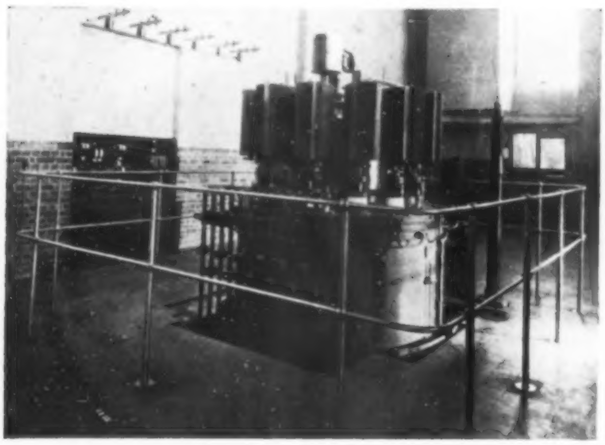
The Automatic Rectifier at Hendon Sub-Station

New features in design give satisfaction for heavy work.

THE first mercury arc rectifier installed in Great Britain for heavy railway service was put into operation at the Hendon sub-station of the London Electric Railway Co. in December 1930, and its satisfactory performance since that date has indicated that the new features incorporated in its design will probably influence the design of future installations for similar heavy work.

Owing to the rapidly increasing load on the Golders Green-Edgware line, the Company decided, in 1928, to construct another sub-station at Hendon, and to try the effect of a rectifier on their class of service. Complete electrical equipment was, therefore, ordered from the British Thomson-Houston Co., of Rugby. This included a 1,500 kw. 615 volt rotary converter, a 1,500 kw. 615 volt rectifier, and transformers, automatic control gear, and all necessary switchgear.

The general appearance of the rectifier will be seen from the illustration. It is a twelve-anode machine, and the



Re tifier (1,500 kw., 615 volts) during erection, showing anode leads.

mercury vapour vacuum pump and rough vacuum pump are carried on the rectifier itself, so that all vacuum connections are able to be made independent of the setting up of the rectifier on site. The motor driving the rough vacuum pump drives also a small d.c. generator furnishing current to the electrical vacuum gauge and relay, and a water-circulating pump whose function is to circulate the water round and round in the cooling jacket independent of the main flow of cooling water, and thus obtain much more accurate temperature control.

The top half of the rectifier, which carries the anodes, is detachable, with a simple mercury-sealed joint, so that the anodes and entire interior of the vacuum chamber can be inspected if desired with the least possible delay. The anodes are provided with tips of a special grade of graphite which has been found to resist all conditions of bake-out, overload, and arc-back, with a complete absence of deterioration.

The six-phase excitation system employed enables the rectifier to carry small loads with certainty, even down to the load taken by a voltmeter, and it enables this to be accomplished without any sacrifice of arc-back protection.

All vacuum seals on the rectifier are sealed with mercury, this type of seal enabling a tight joint to be made easily and without involving any heavy stresses, while in the event of a seal developing a leak during service, an immediate indication of the location of the leak is given by the sinking of a float in the stand pipe which feeds mercury to the seal in question.

The main transformers for supplying the rectifier are single-phase units with air-blast cooling. They carry a low voltage tertiary winding, which is normally used for supplying the transformer blower motor and the internal heater in the rectifier. The secondary windings are protected from the possibility of surges being produced by the arc in the rectifier by a set of horn-gap surge arresters with limiting resistors.

The starting and stopping of the rectifier are carried out by automatic control gear, which also protects it from all emergencies. To start the rectifier either the remote control switch at Golders Green or the local control switch at Hendon is closed. The main oil switch then closes and the transformer blower motor comes into operation. The striking of the excitation arc immediately makes the d.c. voltage available at the terminals of the rectifier. The high-speed breaker and negative circuit-breaker then close, thus putting the rectifier on load. The complete operation, apart from the time occupied in heating, takes only a few seconds. The operation of stopping merely consists of tripping the a.c. and d.c. circuit breakers.

Signal lamps and remote meters enable the operator at Golders Green controlling the sub-station to observe the d.c. voltage and d.c. load at any instant, and also to determine the condition of the rectifier—whether out of service, in process of heating, or on load.

It is well known that the difficulties in operation of rectifiers are greatest during the first few months of service, and it is therefore gratifying to record that the operation of this British rectifier (the first to be installed on railway service in this country) has been thoroughly successful. It was put into service one day before the date promised to the railway company, and as early as the second day of service it carried sustained swings of load up to 4,500 amp., and momentary swings up to 5,500 amp., its full load current being 2,440 amp. Its output during half-an-hour of the peak-load period on its second day of operation averaged over 90% of full load. Although normally it is worked in parallel with the rotary converter during peak-oad periods, it has frequently been allowed to carry the peak load alone, when overloads similar to those of the second day of service have been imposed upon it.

Small loads right down to zero are also invariably carried by the rectifier with complete certainty and stability.

The equipment was not designed to give particularly close d.c. voltage regulation, but actually the drop of d.c. voltage from light load to full load is approximately 6%, and with the rotary converter working shunt the load-sharing between the two machines is practically perfect, from no load to the heaviest overloads.

A disturbance on the system on January 22, 1931, threw an extremely heavy overload on the Hendon sub-station, as this was being fed by the power station at Neasden. It is of exceptional interest to learn that a combined load of a peak value of 12,500 amp. was carried without any trouble.

In consequence of the entirely satisfactory performance of this rectifier, the London Electric Railway Co. has placed a further order with the B.T.H. Co. for seventeen 1,500 kw. rectifiers and five 2,000 kw. rectifiers, together with the whole of the transformers, switchgear, and auxiliary apparatus. This constitutes the largest order for rectifiers yet placed in this country.

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The British Journal of Metals.

Contributions suitable for the editorial pages are invited. Photographs and drawings suitable for reproduction are welcome. Contributions are paid for at the usual rates.

PRINCIPAL CONTENTS IN THIS ISSUE:

Subscription Rates for the British Isles - - - - 24/- per annum, Post Free

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France	Fcs. 155	Canada	$6·20	Denmark	Kr. 22·80
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Published Monthly by the Proprietors, THE KENNEDY PRESS LIMITED, at 21, Albion Street, Gaythorn, Manchester.

Telegrams: "Kenpred," Manchester. *Telephone: Central 0098.*

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INDUSTRIAL UNEASINESS.

ALTHOUGH there has been a slight improvement in the output of iron and steel during the past month, several disquieting features have cropped up which may have a considerable influence in retarding further improvement. Members of the Shipbuilding Employers' Federation, who are the largest individual users of steel in Great Britain, threaten to purchase their requirements abroad unless the great handicap to which they are at present subjected by the relatively high prices is removed. They consider that the rebate of 15s. per ton, agreed upon in 1927, and allowed by British steel makers to the shipbuilders, is quite inadequate to meet changed conditions. At that time, it is claimed, only 12s. 6d. separated the British and foreign-made steel plates, whereas to-day the discrepancy is nearly £2 per ton in favour of the foreign steel. The present position compels the shipbuilders to examine their position very carefully, as they are in a precarious position, and must cut costs wherever possible. The urgency of the need for reducing costs is indicated by the paucity of orders forthcoming. Consider the position! At the end of March, 1931, 132 ships, representing 694,000 tons, were under construction, as compared with 362 ships, of 1,615,000 tons, at the end of last March. The work begun in the March quarter was only 32,685 tons, the lowest figure since the advent of steel shipbuilding, and equal only to one-thirteenth of that commenced in the corresponding quarter of 1930. These figures are terribly eloquent and explain why shipbuilders who have been using British steel are contemplating transferring their orders in future to foreign sources of supply.

The loss to the British steel trade of the orders from shipbuilders would be serious at any time, but at the present juncture it would be almost disastrous. Although some sections of the steel trade have opposed further reductions in the rate, there is reason to believe that the consequences of such transference of orders has been realised, and there is every likelihood of the subject being again surveyed with the object of meeting the shipbuilders. It is believed that the opposition to the revision of prices is due to an anticipation of a change in the fiscal policy of the country. But, although the National Federation of Iron and Steel Manufacturers desire protection of the home market, as a basis for international co-operation, with the object of securing the stabilisation of world prices and market conditions by international agreement, the uncertainty of such a change is recognised by shipbuilders and they are consequently not impressed.

To what extent, if any, the safeguarding of the iron and steel industry would reduce the cost of shipbuilding, or whether tariffs could be successfully used as a means of negotiation for exporting our products to markets now barred by tariffs is very difficult to determine, but it is, however, interesting to note the different views expressed recently by Sir George Hunter and Sir Arthur Sutherland. Both men are eminent in commerce and industry, and both have recently visited America. Sir George Hunter, who is a shipbuilder, has returned with a strengthened conviction that in safeguarding alone lies the industrial future of the whole country. It is his opinion that we are the dumping-ground of the world, because we have no means of negotiating with other countries for a reciprocal reduction in the high tariff walls that prevent us selling them our goods. On the other hand, Sir Arthur Sutherland is a shipowner, and considers that we should not venture on the doubtful path of safeguarding. He contends it is largely a political cry, and not a genuine remedy for our troubles. Tariff walls always operate to the detriment of the public, and he suggests that we continue agitating for a reduction of the tariff walls in commerce. Great Britain, says Sir Arthur, is in a better economic position than the United States.

In view of such strongly contrasted opinions by business men the average person is placed in a quandary in determining the policy from which industry, as a whole, would derive the greater possibilities of a return to prosperity. But it would be distinctly unwise to delay a forward policy until some change in the fiscal system had been effected. Fortunately the iron and steel industry is not waiting, it is actively developing a policy of organisation, productively, commercially, internationally, and imperially, and will be able to make what adjustments are necessary should a fiscal change be made at any time. The question of adequate rebates on shipbuilding materials, however, is one on which an equitable settlement should be made without delay. Shipbuilders have indicated that economies effected in any reduction of material will be insufficient to enable the industry to meet foreign competition, and a meeting has been held with representatives of shipyard trades unions to consider the more economical cost of production and working conditions in the industry.

The ultimatum of the Engineering Employers' Federation to the various trades unions is another problem which will require careful and skilful handling if a disaster to industry is to be averted. It is hoped that it will be possible to reach a settlement by negotiation rather than by any attempt to use force. There was a hope of compromise in the coal situation, as the owners had changed their attitude and conceded the point that wages on a national basis cannot be separated from hours, but settlement hopes are none too bright. On both sides views are divided, conflicting district interest complicates the position, and decision will now need to be made in an atmosphere of impending crisis. There can be no doubt that at the moment many of the staple industries are causing much anxiety, and their effect on each other, though difficult to estimate, must be considerable. Under these conditions it is hoped that all sections will recognise the intricacies of the problems to be faced and will approach them from the point of view of the industries as a whole so that they can be settled in mutual confidence and goodwill.

"Metallurgia" has now removed to more commodious and central offices, and all correspondence should be addressed to 21, Albion Street, Gaythorn, Manchester.

Training Foundrymen.

THE need for some form of national certificate to indicate the successful conclusion of a course of study in subjects embraced by the foundry industry has been recognised for many years, and it is gratifying that a definite move in this direction has now been made. Previously these subjects have been incorporated with examinations held by the City and Guilds of London Institute in mechanical engineering, of which they were in the nature of auxiliary subjects; now, however, thanks to the efforts of the General Council of the Institute of British Foundrymen, with the co-operation of the City and Guilds of London, arrangements have been completed whereby the foundry industry will have independent examinations in keeping with its importance and its peculiar complexities. Syllabuses have been prepared for grouped courses of study in pattern-making and in foundry practice and science, to commence with the 1931-2 session. In pattern-making the course is arranged in two stages in preparation for an intermediate and a final examination, each stage being assumed to occupy two years. In the approved scheme for foundry practice and science, syllabuses have been prepared for a three years' course of study, after which students are expected to be prepared to take an examination in the subjects covered by the syllabus. Successful candidates in these examinations will be granted certificates, countersigned on behalf of the Institute of British Foundrymen by the President of the Institute; success at the final examination in pattern-making entitles the student to a full technological certificate, but apparently the scheme is not yet fully developed in regard to foundry practice and science, as no mention is made of a full technological certificate in this section.

It is noteworthy that the Institution of Mechanical Engineers, in conjunction with the Board of Education, has established a modification of the Institution's national certificate in mechanical engineering suitable for students in foundry practice; this is of an advanced character, and the possession of this certificate constitutes a diploma in foundry engineering of a very high grade. A number of technical colleges are already operating courses leading to this certificate.

The syllabuses that have been drafted in connection with the first of these schemes set out concisely the subjects on which examination questions may touch, and will assist teachers in arranging their matter for purposes of instruction. In many districts there are technical colleges which adequately meet the requirements of these syllabuses, and in other districts there is every likelihood that suitable classes will be inaugurated.

This scheme is, in our opinion, a great advancement on the system that has been in operation, if we may call it a system, and will have a considerable influence in developing foundry knowledge, but there is also a need for the development of skill for which the scheme makes no provision. It will be appreciated that the apprenticeship system has for long ceased to make training in craftsmanship its primary function, and yet a high degree of craftsmanship is probably of greater necessity to-day than at any time in the history of industry. Even under the best of works' systems, the scope of an apprentice is confined to the work and methods adopted by the firm with which he is engaged, and it is generally recognised that no firm, or district for that matter, can claim to adopt the best practice for every kind of work produced. But, in the foundry, an apprentice is usually confined to green sand, dry sand, or loam work, and has little or no opportunity of seeing how other types of moulds are prepared, and his opportunities for obtaining experience in regard to metal mixing, charging and operating furnaces are practically non-existent. It is possible to reduce these difficulties by associating courses of training in craftsmanship and practical metallurgy with any scheme for educating apprentices and young journeymen in the foundry industry, with examinations somewhat resembling those held by the City and Guilds of London Institute in carpentry and joinery. There are, of course, difficulties in adopting a scheme in which practice has a prominent part, but we do not think they are unsurmountable.

The success of the present scheme will depend entirely upon the number of students presenting themselves at technical colleges during the coming and subsequent sessions, to undertake these courses of study, and all who desire to advance the interests of the foundry and allied industries should do their utmost to ensure the fullest possible success to the work that has been inaugurated.

The Cast Iron Research Association.

THERE are many factors essential to the successful pursuit of trade of which the application of science is not the least, but it is very questionable whether industry fully appreciates the real and potential value of scientific investigations and their subsequent application to various branches of industry. At one time it was considered that 25 years separated the development of a theory from its application to industry, but Mr. Pearce, Director of the Cast Iron Research Association, mentioned an instance connected with his Association in which the period just exceeded a year.

We know of no industry to which science can be of greater assistance than the foundry industry, and the Cast Iron Research Association has already done very useful work in various branches of this industry. At the present time, however, the Cast Iron Research Association is at a very critical stage in its history. It has previously been able to carry on its work by virtue of a grant received from His Majesty's Government equal to subscriptions received from the industry. After the present month, June, 1931, it is necessary for the Association to double its income from the industry in order to earn the same grant: on the present subscription no grant will in future be paid at all. The Council of the Association is satisfied that the additional income is not only desirable, but essential, if the demands made by he industry on the Association are to be met. Since it has hitherto enrolled only some 15% of the foundries which could profit from membership, the additional income necessary could readily be raised if a similar 15% were to indicate their intention of subscribing. The great strides made by foreign rivals in this field cannot be ignored, and every iron foundryman should seriously consider the desirability of identifying himself with this Association, so that it may claim the same grant to continue the work for which it was inaugurated and which has been carried on with such signal success.

The Royal Aeronautical Society.

At the last council meeting Mr. C. R. Fairey, M.B.E., F.R.Ae.S., was elected President of the Society for a second term of office. At the same meeting the following were re-elected Vice-Presidents of the Society:—Prof. L. Bairstow, C.B.E., F.R.S., F.R.Ae.S.; Lt. Col. J.T. C. Moore-Brabazon, M.C., F.R.Ae.S.; Mr. H. E. Wimperis, C.B.E., F.R.Ae.S.

Mr. Griffith Brewer, F.R.Ae.S., was elected a Vice-President in place of Air Vice-Marshal Sir Vyell Vyvyan, who resigned from the Council in March, 1931.

Forthcoming Meetings

SOCIETY OF CHEMICAL INDUSTRY.
JUBILEE CELEBRATIONS.

July 13. Opening of Chemical Plant and Research Instruments Exhibition by the President, Sir Harry McGowan, K.B.E., at Central Hall, Westminster, S.W. 1.

July 14. Annual General Meeting at 10-30 a.m. Lecture at 9-0 p.m. on "Dust Explosions," by Professor R. V. Wheeler, D.Sc., at the Home Office Industrial Museum.

July 15. Presentation of Society's Gold Medal to Dr. Herbert Levinstein, at 10-30 a.m., followed by an address by the medalist.
Annual Dinner at Great Central Hotel, 7-0 p.m.

July 16. Discussion of papers.

Correspondence.

"Bliss" Rolling Mills.

The Editor, Metallurgia.

Dear Sir,—Further to my letter published in your May number, I have noted with interest the reply by Messrs. Fraser and Chalmers Engineering Works, which appeared in the same issue.

Whilst I have no doubt that mills of the backed-up roll type will be very generally employed in the future *for work which they can handle with greater efficiency* than can be obtained with the two-high mill, I regret that I cannot agree that the four-high or "cluster" mill will ever entirely replace the modern high-speed two-high mill for all classes of cold rolling work.

The essential advantage of the backed-up roll mill is that due to the possibility of using a smaller diameter of working roll than is practicable in a two-high design for any given reduction and width. It is clear that this advantage is more marked when rolling metal which is both wide and thin. For metal less than 15 in. wide, recent experience has proved that the modern two-high mill will give an efficiency equal to that obtainable from a four-high or "cluster" design, and comparative tests have shown that a backed-up roll mill for narrower strip—that is, having working rolls of relatively small diameter,—has little or no advantage either as regards the ability to effect exceptionally heavy total reductions, or economy in power over a modern two-high mill in which the frictional losses in roll bearings are reduced to a minimum.

On the other hand, we have proved that for wide strip in light gauges—that is, on metal 15 in. to 36 in. wide,—0·005 in. to 0·040 in. thick, the four-high mill is more efficient. Narrower strip, 4 in. to 10 in. wide, can no doubt be rolled most economically in a four-high mill, *if the metal is especially hard*, and extremely light-gauge strip is required, but I scarcely think it can be advantageous to employ such a mill on 2 in. to 3 in. wide mild steel or non-ferrous metal strip.

I quite agree with your correspondent that the British cold-rolling industry must face the necessity of modernising its plant, and whilst it is impossible to forecast with any certainty the direction which future developments may take, I venture to express the opinion that existing two-high mills will eventually be replaced by modern high-speed two-high mills for regular production in mild steel and non-ferrous metal strip in usual commercial gauges up to 12 in. or 15 in. wide, and that four-high mills will be adopted for wider strip and sheets of the same qualities, and possibly for exceptionally thin strip in hard metals and alloys in narrower widths.

The fact that my firm have already installed mills of the four-high type and have others in hand at the moment for cold-rolling strip and sheet metal from 6 in. to 36 in. wide, is sufficient proof that we fully appreciate the possibilities of such mills; at the same time, during the last three or four years, whilst we have in that period developed our four-high mills—being in fact the first British firm to build such mills—we have also received orders for a very large number of two-high high-speed mills fitted with our patent "Flood" lubrication roll bearings, which have proved highly successful for steel strip, in both soft and "stainless" qualities,, and for non-ferrous metals, such as brass and nickel silver.

The actual point at which it becomes advantageous to employ the more elaborate and expensive four-high or "cluster" mill, cannot, I believe, be stated at the present time, and this can only be decided by users with experience with these mills and with two-high mills of *modern construction*. Some misunderstanding on this subject has undoubtedly been caused by the fact that the backed-up roll design has generally been compared with two-high mills of *old types*, and not with modern high-speed mills.

With regard to the advantages claimed for the four-high or "cluster" mills, I notice that "low fatigue" of rolls is included. I scarcely think that the life of working rolls in these mills is as long as is the case of two-high mill rolls. Certainly, with the very small "cluster" mills which have been installed by some firms in this country, the frequent breakage of rolls has proved a very serious addition to the working costs, and has to a great extent cancelled any advantage or economy which would otherwise be obtained.

This is one of the reasons why I do not *personally* favour the use of "cluster" or four-high mills with very small working rolls—that is, on narrower strip for normal heavy cold-rolling work.

In conclusion, I am pleased to note that Messrs. Fraser and Chalmers are in agreement with my correction of the formula for arc of contact given in the original article.—Yours faithfully,

C. E. Davies, Director,
W. H. A. Robertson and Co., Ltd.

The Editor, Metallurgia.

Dear Sir,—We are glad to note that your correspondent fully appreciates the superiority of the Four-High or Cluster Mill for wide sheets and for strip which is especially hard, and it is interesting to learn that he also admits that the modern Two-High Mill will only give an efficiency equal to that obtainable from a Four-High on the softer materials less than 15 in. wide.

It is obvious, therefore, that the Four-High has the advantage all round, as it is only natural to assume that when dealing with soft strip either heavier draughts can be taken or the stresses in the rolls must be reduced, which incidentally negatives the suggestion that the life of rolls on Two-High exceeds that on the Four-High.—Yours faithfully,

For and on behalf of
Fraser and Chalmers Engineering Works,
D. M. Ross.

Correction.

[In our extract of a paper presented at the recent meeting of the Iron and Steel Institute in the last issue of this journal, we regret that a typographical error occurred. The title of the paper should read: "Refractory Materials for the Induction Furnace," and the authors of the paper, "Messrs. J. H. Chesters and W. J. Rees.—Editor.]

Electrical Contractors Visit Rugby Works.

A party from the Birmingham Branch of The Electrical Contractors' Association (Inc.) recently paid a visit to the Rugby works of the British Thomson-Houston Co., Ltd. The party were entertained to lunch when they were received by Mr. H. A. Lingard, a director of the company, Mr. H. N. Sporborg, director and chief engineer, and a number of head office and branch office officials. After lunch the visitors were conducted, in small parties, through the works, where a very interesting time was spent. In the Mazda lamp factory they were able to see lamps in various stages of manufacture.

In the heavy machine shops electrical plant for several important contracts was seen under construction, including a 50,000 kw. turbine for the Ironbridge power-station of the West Midlands Joint Electricity Authority (the alternator for which is being built on site), parts of the two 67,200-kw. turbo-alternators for the Battersea power-station of the London Power Company, a 30,000-kw. turbo-alternator to operate at a steam pressure of 1,200 lb. per sq. in. gauge for the new Ford works at Dagenham, etc. In the transformer department many transformers of various ratings up to 60,000 kw. were in course of manufacture for service in this country and overseas.

In the controller factory it was interesting to note the instrument panel for one of the new P. and O. liners, *Strathnaver* and *Strathaird*, which, when completed, will be the most powerful electrically propelled passenger vessels in the world. The propulsion equipment for these vessels and also for the *Rangatira*, the Union Steamship Co.'s new ship, was manufactured in the Rugby works. Having made an extensive tour of the works, tea was served, and afterwards a demonstration of the company's talking-film equipment in the accoustical laboratory was much appreciated.

Hardening Metals by Rotating Magnetic Fields

By E. G. Herbert, B.Sc., M.I.Mech.E.

The Precession Theory of Hardening.

IN a previous article describing the effect of rotating magnetic fields in setting up fluctuations in the hardness of metals, the view was put forward that the hardness fluctuations are the result of periodic fluctuations of some kind in the systems of electrons, which in turn cause fluctuations in molecular cohesion. It is now proposed to describe some experiments which have been undertaken with the object of developing and testing this theory.

The metal used in the experiments was a hard drawn-steel wire, containing 0·7% carbon, 0·122 in. in diameter, and having a tensile strength of 100 tons per sq. in. Specimens 3¼ in. in length were prepared by grinding and polishing a flat surface the whole length of the specimen to facilitate hardness testing, and the specimens were magnetically treated by placing them in the entrance to the gap in the electro-magnet and revolving them slowly ten times about the axis of the wire. The treatment was applied cold. The hardness was measured immediately after treatment, and thereafter at intervals of 30 mins., and the results obtained from five such specimens are shown in the lower curves in Fig. 1. Each hardness number is the average of 5 to 10 pendulum time tests of five swings.

The result in each case was a sequence of five fluctuations of hardness, the time occupied by successive changes increasing from a few minutes for the first decrease to several hours for the last.

In endeavouring to understand the nature of a phenomenon, it is often useful to form a mental picture of what may be happening, and to test the accuracy of the image by such experiments as may suggest themselves. The picture may be wholly inaccurate, and at best it is likely to be but an imperfect representation of the truth, but the results of the experiments should enable us to correct and fill in details of the picture until we arrive at something approaching a true representation.

It seems clear that the hardness fluctuations shown in Fig. 1 are periodic in character, and that they must be attributed to fluctuations of some kind in the atomic structure of the metal, or in the structure of the atoms themselves, since the more familiar metallurgical changes, such as precipitation, are not generally periodic. The atoms are known to be in a state of vibration, and the electrons in a state of rotation, but it seems impossible that there could occur in these minute structures any kind of vibration or rotation so slow as to require several hours for the completion of a single cycle. Their periodicities are more likely to be of the order of millions per second. There is, however, one possibility to be considered.

If we take a toy gyroscope, spin it, and place it on its stand, we shall see that it has two very different rates of movement. The wheel may be revolving at several thousand revolutions per minute, but the axis moves in a conical path at a much slower rate. The periodicity of this movement of precession may be 4 secs., or, say, 15 r.p.m., when the spin is at its quickest, but as the spin slows down the precession becomes more rapid, until, just before the instrument finally falls from its stand, the rate of precession may be as high as 120 cycles per minute, an eightfold increase. We have, then, a decreasing rate of spin accompanied by an increasing rate of precession, and if we imagine the process to be reversed so that the spin instead of slowing down is speeded up, the rate of precession will evidently become progressively slower. We can, indeed, imagine a condition in which the rate of spin is gradually increased to such a degree that a single precession takes several minutes, and finally several hours. It might go through some such changes of periodicity as are shown in the hardness fluctuations in Fig. 1.

We will now, therefore, put in the outline of our picture by supposing that the metal consists of a multitude of little gyroscopes, that by means of the rotating field we have displaced their axes so as to induce precession, that we have slowed down their rate of spin, and that this tends to increase to some normal and very high value, the increasing spin being accompanied by a slowing precession. Whether the elementary gyroscope consists of the whole of the

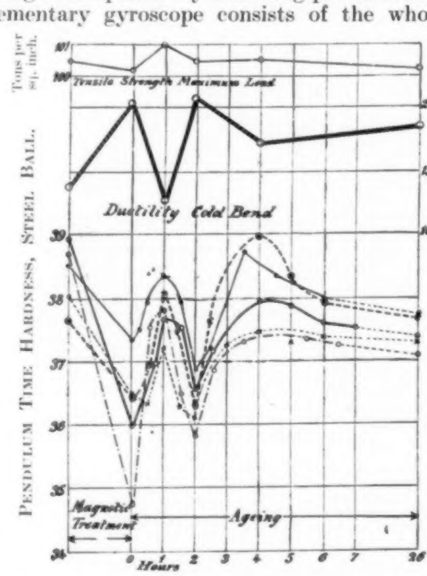


Fig. 1.—Steel wire 0.122 *dia.* 10 *turns in magnetic field, cold; aged. Specimens magnetically treated. Aged to critical points. Broken in tension and cold bend.*

electrons or only some of them, spinning in planetary fashion about their common axis, or whether we have to do with the so-called "spinning electron" rotating about its own axis, we need not at present decide.

It should be noted that the precession of our toy gyroscope is due to the action of an impressed force, that of gravitation, on the spinning wheel, and that the rate of precession depends, not only on the rate of spin, but also on the magnitude of this force. If we increase the gravitational pull (say, by attaching a weight to the gyroscope), the precession becomes more rapid, and vice versa. We must imagine that our electronic gyroscope is acted on by such a force—say, the resultant magnetic attraction of surrounding atoms,—and that its decreasing rate of precession may be due, either to an increasing rate of spin or to a weakening of the resultant magnetism, or to both.

We must now consider that our elementary gyroscope is actually something more—an electro-magnet,—the electrons revolving about their axis being in fact a circulating electric current and generating a magnetic field. We must suppose our metal to be made up of a great number of such magnets disposed in a more or less haphazard fashion, but exercising mutual attraction, and thereby conferring on the metal such cohesion, resistance to deformation, hardness, and other physical properties as it

possesses. If now we cause our elementary magnets to oscillate by putting them into a state of precession, their relative orientations must pass through periodic changes, and it is not unnatural to suppose that they will pass alternately through phases where their relative positions are more favourable and less favourable to mutual attraction. In other words, the cohesion of the metal will undergo periodic fluctuations, and such fluctuations will be manifested by changes in hardness and other physical properties which we can measure.

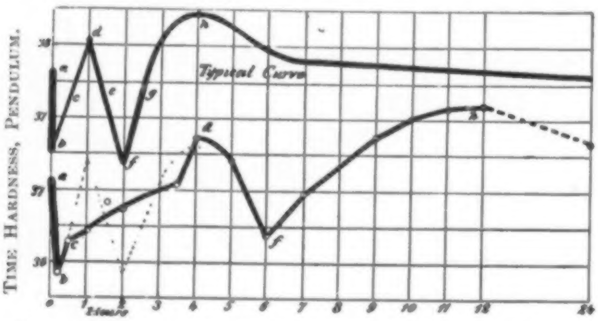


Fig. 2.—Steel wire. 10 turns in magnetic field at "a." One minute in boiling water at "c."

Further, we may suppose that the elementary gyroscope magnets are originally arranged in so haphazard a fashion that their magnetic fields cancel each other, the whole mass of metal having no definite polarity, but when we place the metal in a strong external magnetic field, we orientate the elementary magnets, giving the mass as a whole a definite polarity, and if, as we have supposed, their orientation is slowly fluctuating by reason of the precession that has been set up, we may expect to find fluctuations in the magnetism of the specimen as a whole, and these should synchronise generally with the fluctuations of physical properties, though it by no means follows that the magnetic maxima and minima should coincide with the maxima and minima of cohesion. They might quite well fall between them.

We have now a mental picture of the atomic changes, which, though imperfect in outline, and marred by patches of obscurity or of bareness, is sufficiently succinct for our purpose of testing by experiment, and it is evident that the possibility of inducing fluctuations of so uniform a

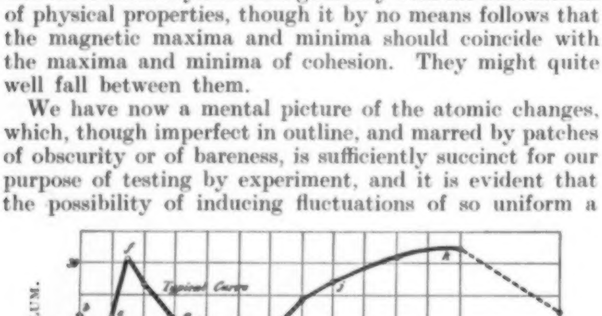


Fig. 3.—Steel wire. One turn in magnetic field at "a." Repeated at "f."

character as those illustrated in Fig. 1 will greatly assist us. Not only can we predict with considerable assurance that a specimen of the wire which has received the standard magnetic treatment will be passing through a definite phase of hardness at a particular period—say, a minimum at 2 hours and a maximum at 4 hours after treatment,—but we can select any particular phase of the fluctuation, such as the 2-hour minimum, apply an external stimulus at that precise period, and see what changes, if any, occur in the subsequent course of the fluctuations. It will be convenient to discuss these experiments in terms of "spin," meaning the rate of rotation of the hypothetical gyroscopes, and "precession" meaning the fluctuation which becomes slower as the spin becomes faster, and vice versa.

Experiments were first made with specimens of the wire, which were given the standard magnetic treatment and were broken in tension at what were assumed to be the critical periods—namely, immediately after, and at 1, 2, 4, and 6 hours after treatment. Several specimens, generally

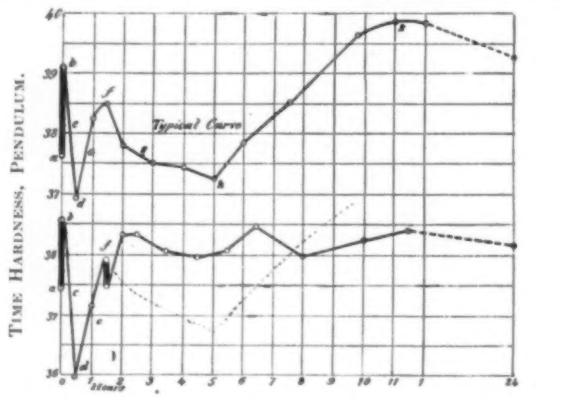


Fig. 4.—Steel wire. One turn in magnetic field at "a." Two minutes in stationary field at "f."

four, were tested at each period, and the average was taken. The results of the tensile tests are shown in the top curve in Fig. 1, and the evidence must be described as generally negative. The changes in tensile strength were insignificant, the variation being less than 1 ton per sq. in.

A further series of specimens were subjected to bending tests, the results being shown in the second curve. In carrying out these tests, the wire was firmly gripped and bent through 90°, then backwards and forwards through 180°, until fracture occurred, the measure of ductility being the number of right angles swept through by the specimen before fracture. We have here very marked fluctuations, of the order of 60% in the ductility of the wire, and an evident correlation with the fluctuations of hardness. The slight changes in tensile strength associated with great changes in ductility may have some analogy with the case, previously mentioned, of the freshly hardened saw-blade passing through a temporary phase in which it is at once

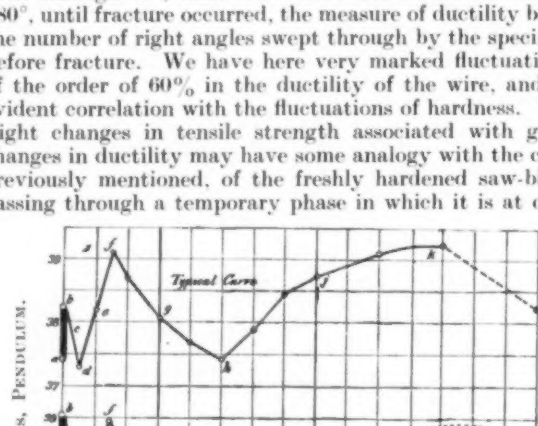


Fig. 5.—Steel wire. One turn in magnetic field at "a." Two minutes in stationary field at "h."

so hard that no file will touch it, yet so ductile that it can be bent into any shape with the fingers. Evidently these are clues to be followed up. So far, we may say that the precession is associated with marked changes in cohesion manifested by fluctuations in hardness and in ductility, these fluctuations synchronising in time and being opposed in phase.

In the next series of experiments, it was sought to effect an artificial change in the rate of spin at a selected phase, and to observe the resulting change in precession. A

typical hardness curve taken from Fig. 1 is reproduced in Fig. 2. The significant points in the fluctuation of hardness are indicated by letters *a* to *h*, and the point *c* was selected for application of the external stimulus. A specimen of wire was magnetically treated, and after the lapse of 30 mins. was plunged for 1 min. into boiling water. The hardness tests were resumed, and the subsequent course of the fluctuations is shown in the lower curve, Fig. 2. There was an immediate increase in spin and a slowing down of precession, the 1-hour maximum being delayed to 4 hours, and the 4-hour maximum to 12 hours. Several such experiments were made, with similar results.

It was now decided to adopt a more rigorous standard in the magnetic treatment for the purpose of securing greater uniformity in the precession. The new standard consisted of a single rotation in the magnetic field, occupying exactly 40 secs., the magnet current being switched off at the instant when the rotation was completed. Typical hardness curves resulting from this treatment are shown in Figs. 3 to 6. It was found possible to reproduce with great precision this curve, which is characterised by six alternations of hardness. It is noteworthy that the typical curves, Figs. 3 to 6, corresponds closely with the curve given by the razor blade treated cold for the first time, Fig. 4 (page 10, previous article), while the curves in Fig. 1 correspond with the second treatment of the same razor blade.

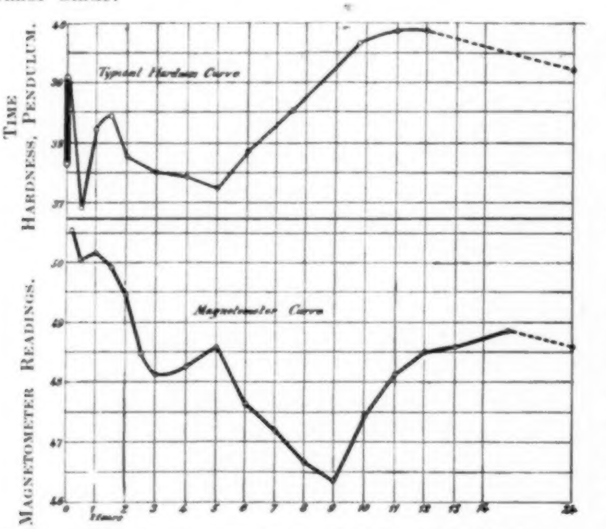


Fig. 6.—Steel wire. One turn in magnetic field. Tested in magnetometer.

Fig. 3 shows the effect of applying the standard magnetic treatment (one rotation in 40 secs.) at *a*, and repeating the same treatment at *f*, the maximum which occurs $1\frac{1}{2}$ hours after the original treatment. The effect was to slow down the spin and speed up the precession, so that the *k* maximum occurred at $4\frac{1}{4}$ hours, instead of 12 hours, as in the typical curve.

Attempts were now made to stabilise the specimens by placing them for 2 mins. in a stationary magnetic field at selected phases. The points selected for these experiments were the maximum *f*, $1\frac{1}{2}$ hours after treatment, see Fig. 4, and the minimum *h*, 5 hours after treatment, Fig. 5. In each case the stabilising treatment set up a temporary fluctuation, but was effective in checking the precession, the effect being similar to that of taking a gyroscope in violent precession and placing it with the axis vertical—that is, parallel with the impressed force of gravitation.

In the next series of experiments specimens of the wire, 2 cm. in length, were given the standard magnetic treatment (one rotation in 40 secs.), and were then placed in a magnetometer. The specimen was suspended from a phosphor bronze ribbon, $0{\cdot}07 \times 0{\cdot}005$ mm. in section and 38 cm. in length. Three complete twists were given to the ribbon, and its torsional moment was counterbalanced by the combined effect of the earth's field and that of a permanent magnet placed 13·2 cm. from the suspension. A mirror attached to the specimen threw a spot of light with a cross line on a scale graduated in centimetres and placed 150 cm. from the suspension. Scale readings were taken at intervals of 30 mins. to 1 hour, and are plotted in the lower curve in Fig. 6, each point on the curve giving the average of ten readings. Comparing the magnetometer

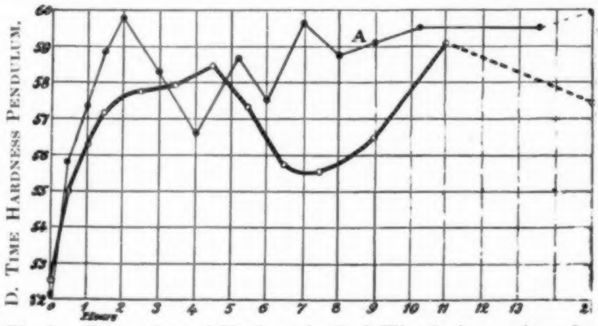


Fig. 7.—Fluctuations of Hardness in Steel Wire during ageing after Quenching.

curve with the typical hardness curve above, it will be seen that well-marked fluctuations occurred, but did not synchronise with the hardness fluctuations. A recurring feature in the many magnetometer curves was the sharp minimum in the magnetic moment at 9 hours (sometimes occurring at $6\frac{1}{2}$, 7, or 8 hours) after treatment. While it has not yet been possible to correlate particular phases of the magnetic and hardness fluctuations, it seems clear that a magnetic precession does occur, as required by the hypothesis.

The view has been expressed that periodic fluctuations essentially similar to those produced by the rotating field might be set up by other than magnetic disturbances, and in particular by quenching from a high temperature and by violent mechanical deformation. Evidence has been given in a previous article, and in order to follow this subject more closely many specimens of the steel wire were quenched in water from 780° C. and tested for hardness at frequent intervals during a period of ageing. In all cases fluctuations were found to occur, and it was intended to correlate these with the fluctuations known to occur in the ductility of freshly quenched steel by making cold bend tests on the hardened wire at critical phases. It was found, however, that the periodicity of the hardness fluctuations induced by quenching differed so greatly in different specimens that this correlation was impossible. This is illustrated in Fig. 7, which shows the hardness fluctuations in two specimens of wire quenched from 780°. One of these specimens (A, Fig. 7) was subsequently given the standard magnetic treatment, with the result shown in Fig. 8. The general similarity of the fluctuations caused by quenching and by the rotating field is apparent.

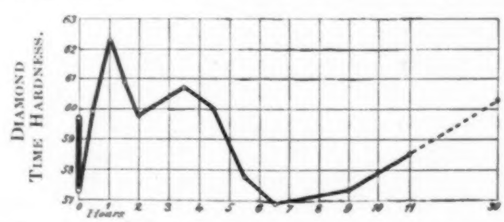


Fig. 8.—Steel wire A. Magnetically treated and aged.

Attention has been given to other hardening processes, those of work-hardening by mechanical deformation, and of the low temperature or "P 3" annealing of work-hardened metals. In order to carry out effectively the low temperature annealing treatment, it is necessary to ascertain the P 3 temperature of the particular metal. This is found by making scale work-hardening tests with

the pendulum at close intervals of temperature, and plotting the results as in Fig. 9. This is the well-known six-point temperature work-hardening curve, which is given by almost all the metals—ferrous and non-ferrous—which have been investigated in this manner. The curve in Fig. 9 was taken from an annealed specimen of steel containing 0·76 C. : 0·59 Mn : 0·15 Si, and it shows the third maximum or P 3 to occur at 216° C., an unusually low temperature for steel.

An annealed specimen of this steel was work-hardened by Cloudburst bombardment, and tested periodically for hardness during the ageing period. It was found to give the RISE, rise, fall sequence of hardness changes, Fig. 10. It was then placed in the electric furnace at the P3 temperature, 216° C., and annealed for 1¾ hours. Hardness testing was commenced on the specimen while actually in the furnace as soon as it had attained the furnace temperature, and thereafter at intervals of 15 minutes. The hardness was found to have risen immediately, and it rose further during the first half-hour of annealing and then fell—again the RISE, rise, fall sequence. The specimen was removed from the furnace and hardness testing was resumed as soon as it was cold, the result being once more the RISE, rise, fall sequence. Thus this same sequence occurred three times in the same specimen as a result of one mechanical and two thermal treatments. It is suggested that these hardness fluctuations, like those produced by quenching and by magnetic treatment, are essentially similar in character, periodic fluctuations due to precession of the electronic systems causing periodic fluctuations in cohesion.

It will be seen that these investigations have led to a new conception of the philosophy of hardening, including quench-hardening, work-hardening, age-hardening, and the hardening of work-hardened metals by low-temperature annealing. We must regard the change effected by the actual hardening process as only the first of a series of fluctuations in cohesion, alternating in a periodic manner, gradually slowing down and damping out during the ageing period.

By the application of the rotating magnetic field it is possible to start these fluctuations afresh, and a judicious selection of the conditions of the magnetic treatment enables us so to regulate their course that the damping out of the new fluctuations will leave the metal with changed physical characteristics such as we may desire.

The older conceptions of hardening based on lattice distortion and on precipitation will still hold the field,

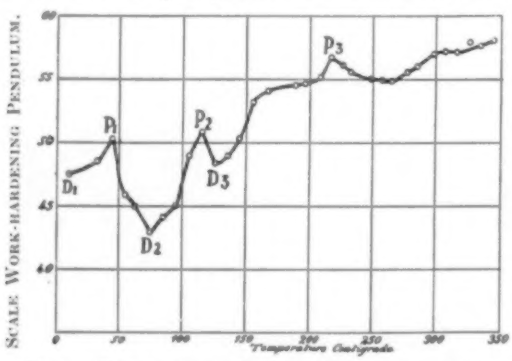


Fig. 9.—Temperature-scale. Work-hardening curve steel. 76c : 0·59 mm. C . 15 Si. annealed.

since both these processes undoubtedly occur and affect hardness. But no explanation of hardening can be considered adequate unless it complies with one condition—it must be shown to be periodically reversible. It must account not only for quench-hardening, work-hardening, and age-hardening, but also for quench-softening, work-softening, and age-softening.

The occurrence of these spontaneous reversals of the hardening process does not depend only on the evidence here adduced. The literature of age-hardening is full of it. Thus, Dr. W. Saran has shown[1] a series of no fewer than sixteen periodic fluctuations of hardness in a quenched aluminium alloy, and Dr. Franz Bollenrath has given[2] some twenty-five instances of hardness fluctuations, including softening, in the ageing of duralumin.

The precession theory has been arrived at by a process of exclusion. It has not been found possible to reconcile the observed phenomena with any other hypothesis. It has been the subject of much experiment, and the evidence so far obtained has been confirmatory.

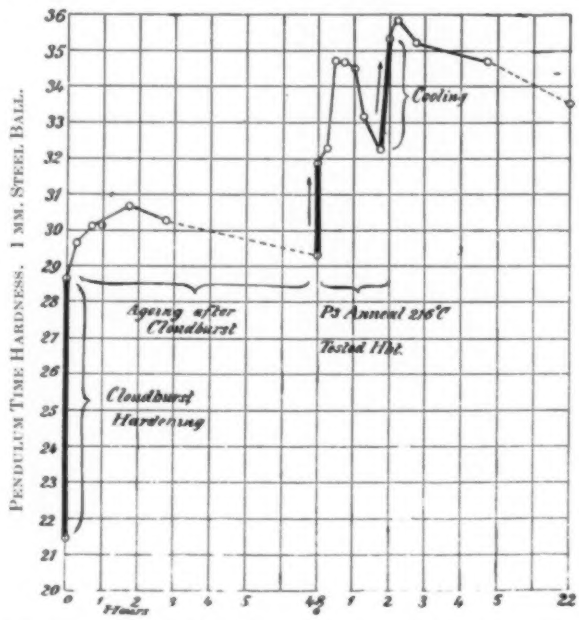


Fig. 10.—(76 C : 0.59 mm. : 0.15 Si.) annealed 750° C. Hardened by Cloudburst. Aged. Annealed 1¾ hours at P_3; temperature 216° C. Tested hot during anneal ; cooled , aged.

A particularly interesting possibility of a practical nature has emerged from these investigations—that of stabilising the metal at a selected phase in the fluctuations set up magnetically or otherwise. It is illustrated by the stabilisation of steel wire in a condition characterised by greatly increased ductility with undiminished tensile strength. Other applications of this principle, of a still more interesting character, have suggested themselves. The experiments are in an early stage, but some striking results have already been produced.

REFERENCES :

1 W. Saran, "On the Course of the Age-hardening of some Aluminium Sand-casting Alloys." *Zeitschrift fur Metallkunde*, Jan., 1931.

2 Franz Bollenrath. "Die zeitliche und örtliche Anderung der Härte bei der Alterung von Duralumin." Abhandlung aus dem Aerodynamischen Institut an der Technischen Hochschule, Aachen Heft 10.

N.P.L. Appointment.

Professor C. H. Desch has been appointed Superintendent of the Metallurgy Department of the National Physical Laboratory, in succession to Dr. Rosenhain. Professor Desch is a Fellow of the Royal Society, and of the Institute of Chemistry, and holds the degrees of D.Sc. (Lond.) and Ph.D. (Würzburg). He is at present Professor of Metallurgy, and Dean of the Faculty, in the University of Sheffield, and was formrly Professor of Metallurgy in the Royal Technical College, Glasgow, and Graham Young Lecturer in Metallurgical Chemistry in the University. He is a Past-president of the Faraday Society and of Section B (Chemistry) of the British Association, and a Vice-president of the Iron and Steel Institute, and is recognised as one of the foremost authorities on metallurgical questions. We understand that Professor Desch will not take up his new appointment until February, 1932, as he had previously accepted an invitation from Cornell University to give a course of lectures there during the winter session of 1931-32.

The New Alloys and——— Machine-tool Design

By Francis W. Shaw, M.I.P.E.

Part V.—Power-actuated Work-holding Devices.*

Means for reducing the chucking-fatigue factor are discussed. The principles and construction of mechanical, magnetic, hydraulic, and pneumatic work-holding devices are described and illustrated.

THE construction of the Forkardt lever chuck is diagrammatically illustrated in Fig. 32. As will be seen from Fig. 33, the jaws, their carrying slides, and the members carrying the levers all may be removed from the chuck body to permit of the

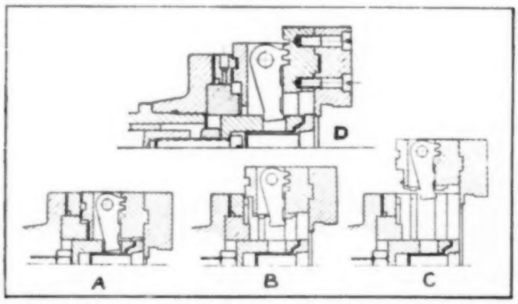


Fig. 32.—Mechanism of Forkardt Air Chuck (A. C. Wickman, Ltd.) showing how the Jaws, Jaw Carriers, and Pressure-lever Carriers can be removed and the position of the Jaws changed for different work-piece diameters.

jaws being moved bodily to accommodate pieces of varying diameter. Note the change in position of the lever teeth in the jaw-slide teeth at *C* and *D*. The lever carriers are held in position by a cam or scroll which, when rotated, brings interruptions in the scroll, into line with the carriers, allowing these to pass through and out of the body. The scroll is to be seen in Fig. 33 immediately behind the body. The holes in this are for the insertion of a tommy bar by which the scroll can be turned. The act of rotating the scroll in one direction screws out the lever carriers until the interruptions are in line with the jaws, and rotation in the opposite direction screws the carriers in again and finally secures them to the body.

Fig. 34 illustrates the application of a Forkardt lever chuck of the type just described to a belt-driven headstock, and the apparent ease of chucking. Air is admitted to the piston at the rear end of the spindle until the pressure-gauge registers the desired pressure, when the supply is cut off. For heavy work, demanding both hands for lifting and inserting, the valve lever would be foot-operated. Contrast this simple turning of a valve lever with the application of a force sometimes amounting to 50 lb. at each end of a chuck lever, and it will be obvious how air-chucking reduces the fatigue factor, particularly when it is realised that the daily number of chuckings may run into a hundred or more. Fig. 34 illustrates the method of chucking for most air chucks, whatever be the type of the jaw-operating mechanism.

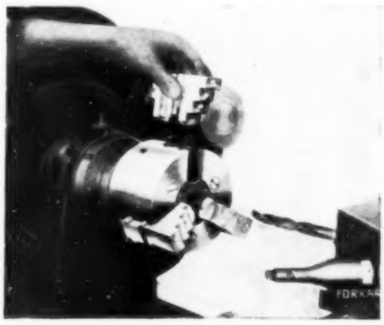


Fig. 33.—External View of Forkardt Lever Chuck. The Jaws, with their Carriers and the Lever Carriers, are removable en bloc.

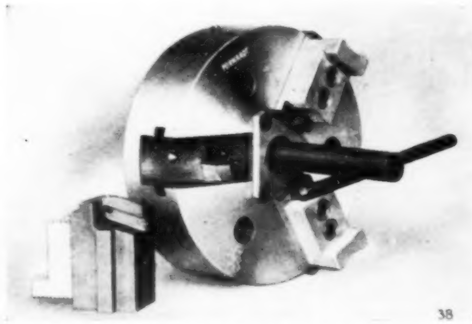


Fig. 35.—Forkardt Wedge-type Air Chuck, with one Jaw and Jaw Carrier removed to illustrate the form of Wedge.

Among other Forkardt chucks, of unusual interest is the type in which the action is through wedges impinging upon projections from the inner extremities of the jaw carriers, to which the jaws are secured by bolts and are

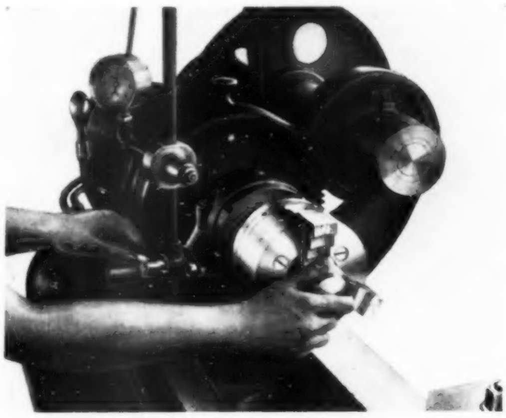


Fig. 34.—Illustrates the ease of air chucking.

restrained from slipping back by serrations. As in the firm's lever chuck, the jaw carriers can be bodily removed with the jaws.

Fig. 35 shows the chuck with one jaw removed with its carrier. The carrier is so formed at its inner extremity as to present a groove which lies at an angle to the axis of the chuck. In the bore of the chuck will be noticed a cylindrical element which is cut away so as to leave projections, which also lie at an angle to the chuck's axis. When the chuck is in use the projections lie within the grooves, and when the cylinder is moved endwise, owing to the angular disposition of the interacting projections and grooves the jaw carriers are constrained to move along their slide-ways in the chuck body. Fig. 36 more clearly illustrates how the projections and grooves fit together, though it does not indicate their axial inclination. Fig. 37 shows the grooved cylinder rotated in the counter-clockwise direction, so that the grooves are disengaged from the projections, permitting the carriers to be slid from the body. The plunger 18, spring 19, and thimble 20 serve a twofold

* *Continued from May issue, page 25.*

purpose—that of preventing the cylinder when in action from turning, and of indicating when the cylinder is in its acting position, the pin projecting visibly from the body unless the cylinder is fully engaged with the jaw carriers. Fig. 35 illustrates how by means of a key the cylinder is rotated.

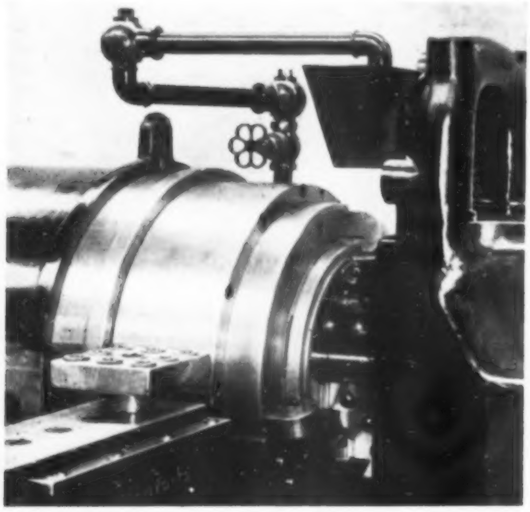
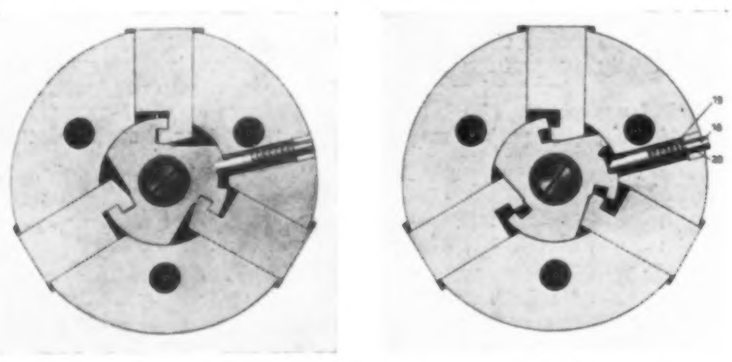


Fig. 38.—Forkardt Chuck on Monforts Automatic Chucking Machine, in which the object is clamped by air for a second operation.

Any lathe provided with air-actuated mechanism is nearly as versatile in a work-holding sense as a lathe provided with hand-operated chucks and the usual face- and driver-plates, and generally the chuck can be utilised as a driver and to support a centre by its bore or by a bush inserted in the bore. And the chuck, its jaws removed, forms a handy face-plate. But it is in its special purpose aspect the lathe so fitted shows its greatest adaptability. Numerous are the types of holding devices already applied and still more numerous those conceivable, but space forbids mention of more than a few of the extant devices. In lathes, for instance, are to be noted the application of air to both internal and external gripping by split or segmental collets, its application for drawing upon the work the clamping levers, bolts, and plates, for operating pivoted jaws, and to jaws provided with many types of pressure-equalising elements.



Figs. 36 and 37.—Forkardt Wedge Chuck. Illustrates how the "wedges" are released to allow the Jaw Carriers to be withdrawn.

Of these many uses Fig. 38 illustrates how an object partly machined is held for another machining operation. The object is centralised by a special adaptor in a special Forkardt chuck, and clamped against the adaptor by three fingers which are drawn back by air. When the fingers are released they fall away radially, giving free vent to the object. The machine is a Monforts automatic chucking lathe.

(To be continued.)

Jubilee Celebrations of the Society of Chemical Industry.

LEADING scientists from all over the world are to attend the Jubilee Celebrations of the Society of Chemical Industry which will take place in London during the week commencing July 13, under the patronage of his Majesty the King. The proceedings will be under the presidency of Sir Harry McGowan, President of the Society, and will comprise a wide programme of scientific discussions, social functions, and visits to industrial centres. The celebrations will open with a reception by the Lord Mayor of London at the Guildhall.

The annual general meeting of the Society will be held in the Duke's Hall, Marylebone, on Tuesday, July 14, when Sir Harry McGowan will deliver his presidential address. In the afternoon a garden party, arranged by the Shell Royal Dutch Oil group, will take place at Teddington. Wednesday will see the presentation of the Society's Medal to Dr. Herbert Levinstein, and the annual dinner at the Great Central Hotel. On Thursday evening a reception is to be given by the President at the Savoy Hotel.

During the celebrations honorary membership of the Society is to be conferred on representative leading members of the chemical industry in each of the world's principal industrial countries, and a feature of the proceedings will be the delivery of addresses by these distinguished scientists on various days during the celebration week. In addition, there will be meetings for the reading and discussion of papers, lectures, and addresses, and an interesting meeting at the Great Central Hotel, when papers presented by the Canadian sections of the Society will be read.

A very wide selection of works and factory visits will be available for members of the Society. Amongst the well-known firms whose works will be visited may be mentioned Achille Serre, Ltd., British Drug Houses, the General Electric Co., South Metropolitan Gas Co., Burroughs, Wellcome and Co., Huntley and Palmer, Ltd., and J. Lyons and Co., Ltd. The Anglo-Persian Oil Co.'s Research Station at Sunbury, and the National Physical Laboratory and Chemical Research Laboratory at Teddington will also be inspected by large parties.

Throughout the week of the celebrations a comprehensive exhibition of British chemical plant and research and recording instruments, arranged by the British Chemical Plant Manufacturers' Association in co-operation with the Chemical Engineering group of the Society of Chemical Industry, will be held at the Central Hall, Westminster. The exhibition, which will be opened by Sir Harry McGowan on Monday morning, will cover the whole range of the industry, and practically every important firm of British chemical-plant manufacturers will be exhibiting. A section of the exhibition will be devoted to the work of the Department of Scientific and Industrial Research, and of the various research associations dealing with the following industries:—Boots, shoes and allied trades; cast iron; leather; linen; non-ferrous metals; paint, colour, and varnish; rubber; wool.

The social side of the occasion has not been neglected, and there will be motor drives, river trips, visits to Oxford, an excursion to Windsor, in which the party will be divided and will visit in turn Windsor Castle and Eton College, and after lunch will be joined by the members from Sunbury, and will proceed by river to Bourne End. Hampton Court will be visited, and, through the courtesy of the Fellows of the Zoological Society, the Zoological Gardens, as well as many conducted tours through London.

The Institute of British Foundrymen.

Annual Meeting and Conference at Birmingham.

THE twenty-eighth annual general meeting and conference of the Institute of British Foundrymen was held at the Grand Hotel, Birmingham, on June 9–12. The conference was officially opened by the Right Worshipful the Lord Mayor of Birmingham (Alderman W. W. Saunders, J.P.), who, in a few well-chosen words, welcomed the members and their friends to the historic city of Birmingham. He said Birmingham realised with pride that it had many old-established engineering firms of world-wide repute, and a good number of foundries whose products were of the highest quality. History was made in Birmingham by the genius of Boulton, Watt, and Murdock, and he believed the spirit of invention of that day was as strong now among the industries. After delivering an interesting speech, he was invited to present the Oliver Stubbs Gold Medal. This honour was conferred upon Mr. John Cameron, of Glasgow, who has worked incessantly to improve the foundry industry, and has been of outstanding service to the Institute, particularly in research work.

At the conclusion of the civic welcome, the annual general meeting was held, when the General Council submitted their report for the session 1930-31, and the financial statement for the year ending December 31, 1930. These were unanimously adopted. Subsequently, Mr. F. P. Wilson, the retiring president, vacated the chair in favour of the newly-elected President, Mr. Andrew Harley, and the remaining officers for the ensuing year were then elected.

Mr. Harley, in his presidential address, commented on the extension of the activities of the Institute in new directions, and said it was imperative for the well-being of the foundry industry that new schemes should operate effectively. It was their aim to raise the character and quality of the whole foundry personnel. The first step in this direction had been the establishment of the certificate schemes. The initial difficulty was that in many localities there were not sufficient boys coming into the industry to make the schemes workable. The local education authorities were ready and willing to co-operate in every way, but they could not make proper arrangements for new classes unless an adequate number of boys were available. The active co-operation of the employers was essential for the solution of this problem.

Dealing with certain aspects of industry in general and the foundry trade in particular, Mr. Harley said the foundryman still suffered from the optimism of the designer in regard to the production of complex shapes, and from his pessimism in regard to the strength of cast materials. Undoubted progress had been made, but a too rigid dependence on test-pieces was responsible for a somewhat academic attitude which was not always supported by actual practice. Research on the fatigue properties of metals and alloys warranted more attention.

The increasing use of engineering equipment had led to some confusion of thought among modern efficiency theorists. Much was said about the desirability of eliminating the human element, but what was actually meant was the elimination of human physical effort. The human element could not be eliminated, especially in a foundry, although the onus of thought and judgment might be passing to some extent from the operative to the administrative and technical staff. They could not afford to eliminate the necessity for observation and deduction on the part of anyone. The more rigid the technical control the greater the breakage when that control failed through not taking into account the human element.

In regard to the foundries of the future, Mr. Harley claimed that they would be cleaner and healthier than the foundries of to-day. Electrical melting would inevitably increase as the cost of electric current decreased. They might live to see the all-electric foundry. The production economies forced on them, in common with all trades, were mainly to the good, and they could only hope that the efforts of the producing community would be emulated in national administration and finance. The production side of industry might well demand equal effort and equal sacrifice in all departments of national life.

A high level of attainment had been reached in the production of commodities, he concluded, but there must be a limit to cheaper production. What should be improved was the technique applied to the distribution of commodities, so that under-consumption and unemployment should be avoided.

Exchange Papers Presented.

A number of papers were considered at a session held on the conclusion of the President's address, among which were exchange papers presented on behalf of kindred associations in other countries. "Some Considerations and Tests for Cast Materials for High Temperature High-Pressure Service," was the title of a paper presented, on behalf of the American Foundrymen's Association, by Mr. G. W. Spring, of Chicago. He briefly traced the progress of the casting industry from the fifteenth century, during which time castings of grey iron, of so-called semi-steel, chilled iron, malleable iron, carbon, and alloy cast steels, and a multitude of brasses and bronzes, have been developed to a high state of perfection. In recent years this development has been continued by the newer nickel-copper alloys, such as Monel metal, tin-nickel-copper alloys of greater hardness, silicon-copper, and steels of nickel-chromium, chrome-molybdenum, chrome-tungsten, and various others of more highly corrosive-resistant type. More severe service conditions have introduced a new factor which has made uncertain the status of some of these products. This factor is the higher temperatures desired for the chemical and mechanical processes which to-day are more efficiently making steam and electrical power, petroleum products, coke, etc.

These higher temperatures have come upon the industrial world with some suddenness, and have brought about increased caution with regard to the materials to be used for the most strenuous service. Mr. Spring reviewed the difficulties encountered in the production of castings for various kinds of high-duty work, and discussed various alloys, and in particular methods and appliances for testing specimens at high temperatures and under corrosive influences.

A paper was presented on behalf of the Association Technique de Founderie of Belgique by Professor H. Thyssen, Jean R. Maréchal, and Paul Lénaerts, in which the theoretical principles of heat-transmission were reviewed. The authors described a modified Despretz method of determining relative conductivities. A series of commercial cast irons were tested, using bars of increasing diameters, and the results obtained are tabulated and illustrated graphically in the paper. The main features indicate that conductivity is higher with an increasing phosphorus content and with diminishing diameters of bars. It is also stated that the size of the graphite lamellæ is proportionate to the diameter of the bars. A commercial inference is drawn in connection with the phosphorus content of economiser castings, whilst pointers are given for the choice of cast iron of high conductivity for industrial applications.

The French exchange paper, on behalf of the Association Technique de Founderie, dealt with the laboratory and the foundry. The author, Mons. M. Arzens, gave a very brief description of the laboratory's duties in regard to the foundry. While realising that the problems encountered are numerous and varied, he did not attempt to discuss them, but emphasised the need for frank and friendly co-operation between the foundry executive and the chemist. Each has something he can given the other, and both science and shop practice would benefit by a full understanding of each other's problems. In his concluding remarks, the author advised the chemist not to regard the practical foundryman asbeing devoid of intellect; at the same time, the foundry executive should not imagine that the chemist has been brought in either to interfere or to spy.

Merchandising Castings.

An unusual subject for discussion at this convention was a paper on the merchandising of castings. This was given by Mr. Eric N. Simons, who emphasised the necessity for foundry sales organisations to adapt themselves to modern conditions, which have as their basis a logical approach as against haphazardness.

The author concentrated primarily on the direct-selling end of the foundry business, and carefully kept in the background such important matters as sales promotion, advertising, publicity, exhibitions, keeping of sales records, circularising, expert demonstration, and all the indirect aids to selling. He confined his remarks to those directions in which he considered that foundry selling is faulty, imperfectly organised, or capable of improvement. No attempt was made to go into extensive detail, for the simple reason that systems are often incapable of effective translation from one foundry to another, owing to ineradicable differences of organisation, the paper being confined to basic principles.

Sands and Sand Testing.

An abbreviated summary of research work on raw moulding sands typical of those in which 90% of iron and non-ferrous castings are made, was given in a paper on "Sands and Sand-testing," by Dr. J. G. A. Skerl. Seventeen samples were examined, for example, from Kingswinford, Erith, Southampton, Scotland, Pickering, etc. A list of experiments which have been carried out on each sand is given, but only a few are discussed in detail. The methods and apparatus for the testing of the mechanical constitution, strength, permeability and refractoriness are described, and the results of these experiments given and discussed. The influence of ramming, milling and moisture content is stressed, and some examples of the practical foundry value of the results are given.

Some of the conclusions are as follows:—(1) Every sand has a definite moisture content at which it is strongest in the green-sand condition. This moisture content is not so great as that required to give the strongest sand after drying. (2) Moulding sands are generally most permeable when they contain the moisture content at which they are strongest in the green condition. (3) Ramming increases strength and decreases permeability, whilst efficient milling increases strength, but does not decrease permeability. (4) The permeability of a moulding sand is largely governed by the silt content, the material coarser than the bonding material but less than the coarse sand grains. (5) The strength of a moulding sand is increased about twenty times by drying. (6) The bonding material is the least refractory constituent of a moulding sand, and, other things being equal, the greater the percentage of bonding material, the less refractory the sand. (7) Milling, amongst other considerations, improves the surface of castings.

Considerable discussion resulted from the presentation of this paper. Mr. Hird, for instance, said that it was his experience that coal dust raised the refractoriness of a sand because the sand grains became coated with a carbon deposit. This was supported by Mr. Hudson, who has carried out much experimental work on moulding sands. Dr. Skerl said that time did not permit him to discuss the results of the whole of the research work, but in regard to coal dust, which created a reducing atmosphere, all the experiments indicated definitely that coal dust reduces refractoriness.

Silicon as an Alloy.

The value of silicon as an alloying element was discussed in a paper presented by Mr. J. Arnott, in which he reviewed the alloys in which silicon is definitely associated with other metals. He laid special stress upon the usefulness of silicon bronze, which until recently has received little attention. These alloys were explored some years ago with the object of finding a substitute for gun-metal with its 10% of tin, which at that time was at a high price and spoken of as likely to go still higher. Silicon was tried as a substitute for tin, and it was found that, when alloyed with copper, 4% silicon was fully equivalent to 10% tin in hardening effect. Using silicon as a hardener, several series were investigated containing nickel, manganese, and zinc respectively, as additional constituents.

Some interesting figures are given, showing the increase of hardness to nickel-copper alloys of the Monel ratio (70 Ni 30 Cu) as a result of adding nickel. Interesting characteristics are shown to be possessed by such an alloy with 2·8% silicon, and the physical properties, which include yield-point, show that a high combination of strength, hardness, and corrosion resistance is available.

Mr. Dews, in discussing the subject, was somewhat sceptical of the superiority of silicon bronze as a substitute for gun-metal. He commented on its high shrinkage, and thought production difficulties would result. Mr. Arnott replied that in the alloy in question the primary object in using silicon was cheapness when the price of tin was very high; with tin at its present price the effect on the cost by using silicon was negligible.

Another paper which was to have been presented at the first session was unavoidably omitted owing to the regrettable illness of Mr. W. C. Devereux, who in consequence was unable to prepare his contribution on "High Duty Light Alloys" in time for the conference. His many friends will hope that he is now completely recovered.

Session at Coventry.

The second session of the conference was held at Coventry, where a civic reception was accorded the members and their friends by His Worship the Mayor of Coventry (Alderman W. H. Batchelor). The conference assembled in St. Mary's Hall, a beautiful old building. The Mayor, extending a welcome to the delegates on behalf of the city, said Coventry had expanded very much during the past twenty-five years. This was due to the adaptability of its people. Coventry had proceeded from the manufacture of ribbons and silks to watches; from watches to bicycles; from bicycles to motor-cars; and they were still holding their own and producing the best motor-cars in the world. In Coventry, he said, there was a scheme of apprenticeship for the training of young people which was unique, and which was being held up as an example by the Board of Education. They were glad to be able to co-operate for the benefit of the industries. A great deal of such good work had been done under tremendous difficulties, owing to the inadequacy of the Technical College accommodation, but the city was about to start upon the erection of a new Technical College, and they hoped to be able to equip it in such a way as would gratify industrialists.

Only two papers were presented at this session, the first by Mr. L. H. Pomeroy (managing director of the Daimler Co., Ltd.), being read *in extenso*. He dealt with the relationship between the engineering and foundry trades

(*Continued on page* 60.)

Recent Developments in Cast Iron and Foundry Practice in Great Britain

By J. G. Pearce, M.Sc., M.I.E.E.

(Director British Cast Iron Research Association)

A few contributions made by the British Cast Iron Research Association to the study of cast iron and foundry practice during the last few years, from a paper presented at the annual conference of the Institute of British Foundrymen.

It is particularly appropriate that, in the city in which this Institute was founded, and in which such a closely-associated body as the British Cast Iron Research Association has its headquarters, the author should pass in review the work of the Association since its inception. The Association's field of work is the founding industry, its raw materials, its methods and processes, and its plant and equipment. In order to reduce this review to measurable proportions, it is proposed to consider three main points likely to be of general interest: moulding sands, the cupola melting furnace, and the properties of cast iron itself.

Moulding Sands.

The work on moulding sands can be discussed very briefly, because a separate paper by Dr. J. G. A. Skerl, who has been responsible for the work carried out by the Association, deals with this subject in detail. Moulding sands form a most important raw material of the foundry, and it is estimated that the aggregate cost of sands and refractories to the trade is at least a million sterling per annum. Other countries—not so blessed with good natural and easily-available moulding sands—were forced to begin systematic tests at an earlier date, but there is no doubt that the special character and variety of British sands demands a British approach. The first step taken was to devise a set of tests which can be used to determine those properties of moulding sand which are important to the founder. It was essential that comparable results should be obtained between different sands and on the same sand at different stages of its life, with differing moisture contents, ramming densities, and so on. The report prepared under the direction of the Sands and Refractories Sub-Committee, was circulated in printed form in May, 1930 (after the methods had been tested over a period of several years), and the Council decided to make this available to any interested persons at a small charge,[2] in view of the importance of the common use of the same apparatus.

For research work on moulding sands, the whole of the tests outlined in this report are necessary, but for the purposes of daily foundry control, two tests only are needed, a strength and a permeability test. Simple apparatus was designed for the purpose of making these two tests, and is available to all at a small charge from the suppliers approved by the Association.* The price of these two pieces of apparatus together is something like one-fourth of that required for corresponding American apparatus.

The Association has now applied the tests outlined in the above report[2] to no less than seventeen representative sand deposits in Great Britain, the red sands of the Midlands, the yellow sands of the Thames estuary, the rotten rock sands of Scotland, and various other typical deposits. Over 90% of the castings made in Great Britain are made in sands of which these are types. The result is that a unique body of information has been collected which can be utilised through the Association's experts by any foundry in the country. This remark incidentally applies equally to steel and non-ferrous foundries as to grey and malleable-iron foundries.

At the present time the Association is working on core sands and refractories for cupola linings and other furnaces. Facing-sand mixtures in the various foundry areas are being studied in the light of castings made, so that it will soon be possible for the founder to purchase core and moulding sands and refractories to a definite specification. It is estimated that the application to the industry as a whole of present knowledge of sands and refractories would result in savings of at least £100,000 per annum.

Melting Practice.

The Association has always consistently taken the view that the cupola is the heart of the foundry, in which good raw material may be spoilt or the best use made of indifferent material. The temptation during the war to get from a particular size of cupola the maximum amount of metal per hour was considerable, and the rapid-melting type became very popular. This type, however, involves the supply of a greater volume of air than is necessary to burn the coke and melt the metal, the excess being consequently available for oxidation of the metal and the elements in it.

The Soft-blast Cupola.

Under the guidance of Mr. J. E. Fletcher, the first step taken was to evolve a design of cupola which has since become known as the "soft-blast" type. The design naturally varies with the requirements of each particular foundry, but it is characterised by an ample height from tuyeres to charging hole, a generous wind-belt, a low air-pressure, a single row of tuyeres, rectangular in section, and about twice as wide as they are deep, and flared out towards the inside of the cupola, thus offering the least possible resistance to the admission of the air, whilst giving efficient penetration of the coke bed. This type of cupola does not yield such a large output per hour as a corresponding size of the rapid-melting type, or, to put the same fact another way, a larger capital outlay is required on this type of cupola to produce a given output per hour. Ample evidence is available, however, to show that this is more than offset by the improvement in quality of the material made and diminution of losses and wasters. Several hundred cupolas have been remodelled on this basis, and, in spite of the almost invariable necessity for making use of the existing blowing equipment, they are giving excellent service. The coke consumption, excluding the bed, is usually about 10 to 1 for engineering castings, and where scrap is light, runs are long, and composition suitable, as in light castings, 13 or 14 to 1. Since most foundries have melting plant in excess of requirements, the large majority of soft-blast cupolas at work are reconstructions of earlier designs.

The "Balanced-blast" Cupola.

More recently Mr. Fletcher has evolved another type of cupola for which a British patent†, held by the Association, has been obtained, and foreign applications have been

* B.C.I.R.A. Permeability Apparatus (British Patent 327,306). Price £5, less 25% discount to B.C.I.R.A. members and approved technical institutions, from Samuel Platts, 6, Holly Street, Sheffield. B.C.I.R.A. Compression Apparatus. Price 70s., less 10% discount to members and approved technical institutions, from Geo. Salter and Co., Ltd., West Bromwich.

† British Patent 333,322.

granted and are pending. This type is known as the "balanced-blast" cupola, and at the present time not more than a dozen of these cupolas are in operation, although they are spreading rapidly.

The Association was anxious to have definite proof in practice that the principle could be applied to all sizes of cupolas, types of charge, etc., and has hesitated to advance any claims until they have been fully substantiated. This cupola is supplied with a row of main tuyeres and two or more rows of smaller auxiliary tuyeres, all in and fed from the same wind belt. The particular feature of the cupola is that the main lowermost tuyeres are controlled by finely adjustable screw valves, so that the air admitted to these tuyeres may be regulated, the tuyere apertures between the valves and the cupola lining being designed so that, though the annular stream of air passing the valves is at a high velocity, the impinging effect on the coke is reduced so as to produce a softer blast. The tuyere system for a 51-in. bore cupola is shown in Fig. 1. The construction permits the valve to swing aside in order to get at the tuyere if required, the valve stem being hollow, so as to permit inspection and allow of temperatures, gas pressures, and gas analyses in the coke bed to be taken if required.

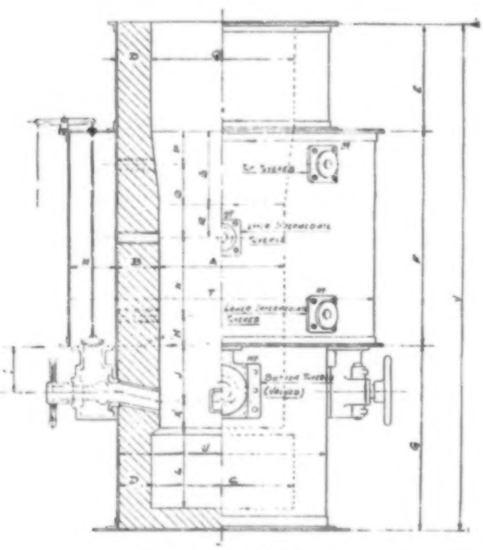


Fig. 1.—Balanced-blast Cupola.

The upper tuyeres can also be inspected while the cupola is running.

It is obvious that for a given air supply pressure the throttling of the valves at the main tuyeres will result in an increase of pressure in the wind belt, and consequently the passage of more air through the upper tuyeres. Thus, a balance of air supply can be maintained between the main tuyeres and the upper tuyeres to suit the requirements of working. It is found that one particular setting of the main valves, readily obtained in practice, is suitable for a particular type of charge, size of scrap, type of coke, etc. Towards the end of the melt the necessary reduction of air supply can be obtained by a further throttling of the main valves. When the type of charge, size of scrap, type of coke, etc., is changed, a suitable alteration in the valve openings may be made to obtain the best results. The cupola, therefore, can be controlled by the foundryman to suit any melting conditions which may arise, and, after a little practice, it is found that, beyond the determining of the best valve position for the early part of the blow, no other valve adjustment is needed until, during the last half-hour or so of the blow the valve openings may be further throttled. Provision is also made for clearing away slag obstruction from the mouth of any tuyere by means of a simple valve which can be made to cover the inlet to the main valve. After the obstruction has cleared, the de-slagging valve can be raised, and the main tuyere, thus cleared of slag, functions again. In Fig. 1 this valve is shown as a dish type. When the cupola is running this is, of course, normally above its seat, and is only released when it is necessary to cut off the air supply while slag obstructions are melted away. The coke bed, of course, is somewhat heavier than with the soft-blast type, on account of the extra rows of tuyeres, but the peculiar conditions of operation appear to result in a much less oxidising atmosphere inside the cupola, with the result that the bulk of the coke bed is recovered intact, a coke recovery of about 50% being normally expected and obtained.

In the original trials of this cupola the coke consumption for a 54-in. bore furnace was gradually reduced to 5·6% (nearly 18 : 1). The metal temperature was excellent and uniform throughout the melts, being between 1,400° and 1,425° C. Less patching is required, and the cupola is cleaner after the day's run than with an unaltered normal-type cupola. The melting rate was increased from the normal 10 tons to nearly 14 tons per hour. In the working of these particular 54-in. bore cupolas, the service results show that a coke saving of 33⅓ may be expected, and in some cases as much as 50% can be saved. The reduced coke consumption diminishes the sulphur pick-up.

In practice, the "balanced-blast" cupola has shown the advantage of being able to control the air supply over the entire depth of the coke bed. By this elastic control the whole of the coke bed is maintained in an incandescent state at high temperature, thus acting as a thermal storage column for the prevention of variations in the casting temperature of the metal.

This has been proved in even the smallest cupola (24-in. bore), where, for reasons which do not concern the cupola, the blast has been shut off for intervals of as much as 30 mins. during a 2 to 2½-hour blow. The metal was quite fluid and satisfactory when tapped.

Further developments of the balanced-blast principle are in progress, in the direction of the remelting of metal charges containing high percentages of steel or other low-carbon metal, with little or no carbon or sulphur pick-up, accompanied by a high casting temperature. It is estimated that the adoption of the balanced-blast cupola by the industry as a whole would result in an annual saving in coke on a very conservative estimate of at least £100,000 per annum, apart from the other advantages. With many foundries coke economy is of small importance, and metal quality is vital. In the author's view this design will give the cupola a new lease of life.

Growth and Scale-resisting Iron.

It is well known that cast iron, when subjected to prolonged heat, increases in volume, and this change is called growth. It varies according to whether the heating is in air or *in vacuo*, whether it is under oxidising or reducing conditions, or whether the temperatures are fluctuating and intermittent or regular and continuous, but it is experienced to a greater or lesser degree under all conditions.

For the past quarter of a century the compositions of growth-resisting irons have been derived from the classic work of Carpenter and Rugan, whose investigation was published in 1909. The broad conclusion from this work is that growth is due to the presence of silicon, and that consequently, to diminish growth, it is desirable to diminish the silicon content. It was shown that white irons grew very much less than grey irons, and the lower the grey iron with respect to the silicon content, the more satisfactory it became. There is no doubt of the correctness of this as far as it goes, and in ordinary irons the best for heat-resistance are those lowest in silicon. This state of affairs persisted until the end of 1928, and an excellent summary of the state of knowledge at that time is provided in the Association's *Bulletin* for April, 1928. Later in that year discoveries made in the laboratories of the Association by Dr. A. L. Norbury and Mr. E. Morgan showed that it is possible to diminish the growth of grey cast irons below the best figures obtained from the very low silicon irons by the converse process of increasing the silicon content to above

4%. This astonishing discovery has since that time been carried a good deal farther, and the first part of the scientific evidence respecting the superiority of the high silicon irons is contained in a recent paper by Norbury and Morgan.[3] It has given rise to a new series of heat-resisting irons covered by a British patent* and pending applications, and has also been covered in foreign countries.

Properties of "Silal."

These alloys have been registered under the trade name "Silal." The bulk of the Silal normally manufactured (by members of the Association) lies between 5 and 7% silicon. The carbon content is inevitably low in such an iron. A 2·5% silicon iron will naturally take up about 3·5% of total carbon in the cupola, while an iron containing less than this carbon content will usually tend to increase to that figure. At 5% of silicon, however, the corresponding carbon value is about 2·8%, and at 10% of silicon about 1·6%. At 15% of silicon the figure is about 0·8%. The Silals are low in carbon, and their growth-resisting properties may be ascribed to the following causes :—

(1) In a well-made Silal the basic structure of the metal is entirely ferrite and fine graphite, or at most contains a fine network of pearlite which disappears on the first heating. Analyses of these and other irons referred to below will be found in Table I. The bulk of ordinary engineering irons are pearlitic in character, and the breakdown of the carbide of the pearlite is only a question of time and temperature, unless stabilised by chromium, the addition of which is limited if machinability is required. When a fully pearlitic iron is converted to the fully ferritic condition by heat, the increase in volume is about 2%. In ferritic Silals, however, there is no combined carbon to graphitise on heating, and consequently no growth from this cause.

(2) Ferrous alloys, when subjected to heat, invariably form on the outside a coating of scale or oxide. Frequently this friable scale will peel or fall away, and expose a further surface to oxidation, the process thus going on until all the iron has been oxidised. The formation of iron oxide involves considerable volume increase, which represents the final part of the growth phenomenon, the first stage of which is the conversion of iron carbide to iron and graphite (see above). In the case of ordinary cast iron, the presence of graphite cavities offers to the oxidising gases a series of channels into which they penetrate and cause oxidation to proceed to the inside. This not only produces of itself a partial increase in volume, but the resulting internal pressure yields minute cracks in the interior, which again increase the area for gaseous attack, and the process goes on continuously. Scaling and growth, therefore, represent the external and internal phases of the one phenomenon. Silal, when properly made, contains nothing but extremely fine graphite, so that there is practically no entry offered to the oxidising gases. It is also known that silicon in solution in iron increases the scaling resistance of the material, as is shown in the case of the silicon steels, and the present discovery has reconciled the whole of previous experience with cast iron with experience on steel. It was previously impossible, on account of the apparent contradiction of heat-resistance requiring high silicon for steel and low silicon for cast iron, to reconcile the two on any rational basis. Reference is made below to further researches showing that there is a tendency for fine graphite to be associated with ferrite in the casting, and normal graphite of the flake type to be associated with pearlite. If the melting conditions cause the production of flake graphite, even the Silals will contain pearlite. It is scarcely necessary to add that pinholes, blowholes, and other gaps in the structure, due to gases or other causes, must be avoided, as they are far worse in their effect than graphite cavities, being larger and offering an extended area for attack.

(3) Silicon in solution in iron raises the pearlite change-point, or the point at which graphite will dissolve on heating, and be redeposited on cooling. It is obvious that any ordinary cast iron required to withstand heat will not last very long if it is called upon to be heated beyond the pearlite change-point, as every time it is cooled down, a little more permanent growth takes place. Silicon, however, raises this point very markedly, and the change-point on cooling rises from about 685° C. at 2% silicon to about 1,000° C. at 7·5% silicon. In these problems it is often the last 50° C. or so that counts, and the beneficial use of high silicon enables a much higher temperature to be withstood without taking the metal into the danger zone.

The advantages of silicon have thus been used in Silal in every possible way, and the disadvantage, that of its graphite-coarsening action, is rendered negligible by the particular method of manufacture adopted, which induces a very fine state of division in the graphite. The discovery has recently been confirmed in Germany, but it is interesting to note that from various parts of the world papers are still being received from various investigators showing that silicon is bad in heat-resisting irons.

Mechanical Properties of the Silal Irons.

While tensile strengths of the order of 10 to 16 tons are usual with this material on standard test-bars, there is no doubt whatever that silicon in solution hardens the material, and hence the ordinary Silals are not so good mechanically as the best engineering irons. Alloy types are being developed. Thus, on a Silal step-bar casting, on

TABLE I.

Fig.	T.C.	Si.	Mn.	S.	P.
	%	%	%	%	%
2A	3·55	1·95	0·50	0·08	0·72
2B	3·71	1·29	0·62	0·09	0·59
2C	3·50	0·68	0·35	0·18	0·64
2X	3·25	2·16	0·92	0·12	0·38
2Y	3·09	1·68	1·23	0·09	0·53
2Z	2·97	1·01	0·71	0·12	0·26
3A	3·16	2·06	0·39	0·14	1·12
3B	3·24	1·41	0·56	0·10	0·55
3C	3·42	1·17	0·39	0·13	0·60
3XY	2·93	0·76	0·44	0·09	0·29
3Z	2·5	0·68	0·15	0·04	0·05

the $\frac{1}{4}$-in. section, the Brinell hardness was 241, and on a 1-in. section the Brinell hardness was 209. In a ferritic iron containing 2 to 2·5% silicon, the Brinell hardness would be about 180. The Association does not recommend this material for engineering castings for prime movers, as it believes the growth problem is solved so far as this purpose is concerned, and requirements can be met satisfactorily by the high-quality engineering irons. The new material is being applied particularly to such castings as firebars, stoker links, furnace castings, melting pots, retorts, and the like. It is easily machinable up to the silicon limit mentioned above, and does not present any difficulty in the foundry if reasonable care is taken and experience available is used.

Tests, which have not yet been published, have shown that at 850° C. the high-silicon irons are stronger—that is to say, they deflect less rapidly under load than low-silicon irons, such as high-quality engineering irons. There is no need to repeat scientific evidence, which has already been given elsewhere,[3] as to the growth-resisting and scale-resisting properties of Silal irons. For example, a 7% silicon iron, after heating to 850° C. for eight days, was virtually unscaled, while a 2% silicon iron, after heating to the same temperature for six days, was coated with scale about $\frac{1}{20}$ in. thick, and oxidised iron about $\frac{1}{20}$ in. thick.

* British Patent 323,076.

Conditions of Melting and the Germ Theory.

The Association has played considerable part in developing what may conveniently be termed the germ theory of cast iron. One of the most baffling phenomena the founder has to face is the variation in properties of cast iron, even when he has, as far as is humanly possible, kept everything the same with respect to raw material, manufacturing conditions and labour. It has been shown by Continental investigators that, when cast iron is heated well above its ordinary melting temperature, the graphite in the casting is obtained in a finer state of division. The term "superheating" is often loosely used to mean heating above the melting point, but every cast iron has to be superheated before it can be cast, because it must be melted to a temperature well above its freezing point. Superheating, however, implies melting to, say, 100 or 200° C. higher than ordinary foundry-melting temperatures. Experiments carried out by the Association[4] in the crucible showed that it is possible from the same composition of iron to make two entirely different structures, the one consisting of ferrite and very finely-divided graphite, a structure unfamiliar to most people in cast iron, and the other containing the ordinary familiar pearlite—normal graphite. Both are good, although the fine-graphite iron shows the differences which might be expected from a softer material. In the ordinary way, an iron consisting wholly of ferrite—fine-graphite—contains very low combined carbon. Frequently, however, an iron structure appears as a mixture of ferrite—fine-graphite and pearlite—normal-graphite, with the result that the combined carbon content determined by analysis is the average of that obtained in the two structures.

While the pearlite iron pipes or "feeds" in the ordinary way, and shows the usual sinking in runners and gates, the fine-graphite type finishes practically flush and level in the riser. Another singular difference between the two is that the fine-graphite type requires much more silicon to keep it grey. Thus, a 1·2 in. sand-cast bar of pearlite—normal-graphite with 3% total carbon will be just turned grey with 0·85% silicon, whereas the fine-graphite type requires about 1·25% silicon. It is believed that the phenomenon of inverse chill appears when patches of this fine-graphite structure occur in a casting which had not sufficient silicon to keep it grey, although there is ample to soften the remainder of the metal of the usual pearlite—normal-graphite type. It must be emphasised that these two types of structure can be had from identical compositions, and it has been proved possible to take an ordinary pig-iron, to melt it, and cast it in the fine-graphite form, and then to remelt it, and, after suitable treatment, to recast it in the normal-graphite form.[5] The difference, therefore, does not depend on chemical composition, and the question arises: To what is the difference due? In adopting the germ theory as an explanation, the Association is merely using a working hypothesis which so far explains these effects most satisfactorily, but which is known to be incomplete in certain respects. The germ theory will, without hesitation, be abandoned when a more satisfactory explanation is available. Very briefly, it is believed that the ferrite—fine-graphite structure appears when the metal solidifies free from the presence of fine-graphite particles in the melt, whereas the pearlite—normal-graphite structure appears when the metal has graphite particles present undissolved when the metal is molten. In the latter case the flakes are made by building-up on the nuclei, which are there in the first place. The experiment related above regarding pig-iron was carried out by melting the pig under such conditions that all the graphite flakes were removed, when the metal solidified ferrite—fine-graphite. After remelting, the graphite particles were restored artificially, when the metal solidified pearlite—flake graphite. The process of putting graphite back into the melt is conveniently referred to as "inoculation," and this method may be responsible for important commercial developments.

The process of superheating is one method of increasing the extent to which the graphite is dissolved, and if applied long enough and at a sufficiently high temperature, will enable the whole of the graphite to go into solution. Under such conditions superheating yields the super-cooled or ferrite—fine-graphite structure, which is not usually desirable in the foundry, when mixed with pearlite, as is usual with cupola melting. On the other hand, superheating may, if carried out to a limited extent, diminish the size of the nuclei in the metal without eliminating them, with the result that the ultimate graphite size in the casting is diminished. It is obvious that superheating entails risks if it is carried to the point at which the graphite completely disappears, whereas the risks attendant on indiscriminate superheating can be offset and mitigated by the artificial inclusion of graphite at a later stage—that is, by inoculation. It has not been found necessary to superheat in order to get rid of graphite. In laboratory experiments it is possible to clear a melt of graphite by stirring it with a steel rod or by stirring in some finely-divided steel turnings. There would appear to be a possibility of producing controlled cast iron by the complete removal of graphite by superheating or other devices, and by the mixing in of a suitable inoculating material calculated to yield pearlite with graphite in as fine a condition as is consistent with the production of pearlite. It is particularly important to note that fine graphite tends to be associated with ferrite, whereas normal flake graphite tends to be associated with pearlite, and the dividing line which, of course, will vary to some extent according to casting thickness and other factors, appears to be reached with a flake length of about 0·02 mm. It has been possible, however, by various methods to ensure the productiou of pearlite in mixtures containing graphite below this size.

If the above theory is correct, it is fortunate for the foundry that, under ordinary conditions of melting, the time of passage through the cupola and the temperature reached are insufficient to dissolve the whole of the graphite present in the pig and scrap of the charge. Obviously, the larger the graphite—that is, the coarser the structure in the charge—and the less efficient the cupola, the less likely is the graphite to dissolve completely. Hence the importance of cupola melting in the production of good cast irons. Melting temperature appears to be a matter of very much greater importance than pouring temperature.

Silicon no Criterion of Strength.

It has long been evident that some modification is required of the conventional theory of the graphitisation of cast iron by silicon. Cast irons of similar mechanical properties and similar sections are found in practice to contain widely differing silicon contents. Conversely, irons of the same silicon content have widely different properties. The author recently compared the silicon contents of a series of irons cast in the form of bars 1·2 in. in diameter, some English and some German. The tensile strength of something like eighty different mixtures varied from below 8 tons per sq. in. to about 21 tons per sq. in. The silicon contents varied from 0·6 to 2·75%, and there was no relationship whatever between silicon content and strength. In fact, the irons of the lowest and highest tensile strengths mentioned had about the same silicon content, 2·75%, and the iron of lowest silicon content mentioned had about 15 tons tensile. The remaining figures were scattered over the whole field. The germ theory not only lays stress on the carbon content, which obviously affects the issue, but upon the way the carbon content, both in quantity and distribution, is affected by the conditions of melting. The successful working out of this theory lies at the root of the possibility of producing controlled cast irons—that is, irons whose mechanical properties can be predicted in advance from the composition and conditions of melting.

Fracture.

It will be evident from what has been said above that irons of similar composition may differ totally in fracture, either with respect to the difference between the fine-graphite and flake-graphite types, or in the pearlite-flake-graphite range itself, as between the larger and smaller

flakes. This work has, in fact, shown scientific evidence for the preference the British founder has always displayed for judging metal by fracture, for the Association has shown that what is called the fracture of iron, whether pig or cast iron or malleable iron, is due to the size and distribution of the graphite flakes it contains, and the whole of the conclusions drawn from the germ theory can be expressed in terms of fracture. Thus, if a foundryman wishes to open the grain of his castings, he includes in the charge pig of a lower grade number—that is, a pig containing coarser graphite. Conversely, to close the grain, he includes an iron with a closer fracture or higher grade number, and so on. The whole of ordinary experience in fracture can be restated in terms of the germ theory.

The Strength of Cast Iron in Relation to Design.

British Engineering Standards Specification 321 of 1928 revolutionised the testing of cast iron in this country. In this first general B.E.S.A. specification ever devoted to iron castings, the round test-bar was adopted as standard, and the section of the bar was varied according to the thickness of the casting it was required to represent. The Association immediately concentrated on the round bar for experimental work, which it had already proved to be more satisfactory in many respects than the rectangular bars, and an investigation was begun with the object of ascertaining the relationships between the various mechanical tests, since, if the tests can be related, their variety can be reduced and the cost of testing diminished. Secondly, it was desired to ascertain the relationship between the strength of test-bars and the strength of castings varying in section. The work so far done on this has shown that tensile, transverse, and compression tests substantially measure the same property of cast iron,[6] and that, given one test, the remainder may be estimated to a reasonable degree of accuracy for the same iron. For purposes of this comparison it is necessary to express the transverse test as a rupture stress in tons per sq. in.[7] The transverse strength is then about 1·8 to 2·2 times the tensile, and the compression strength about four times the tensile strength. It has also been shown that the strength of cast iron (tensile, compression, and transverse) varies continuously with section,[6 8]—that is, the strength is least in thick sections, and the change is a regular one until the thinnest section is reached, at which the metal remains grey. White iron is very strong, but its brittleness is a disadvantage, and this renders the strength properties very erratic. For a given series of mixtures in the same foundry—that is, under the same melting conditions, the series containing the higher silicon will be weakest, and the least silicon strongest within the given range. For bars of a given size produced under the same melting conditions, the highest silicon is the weakest and the lowest silicon strongest, also within the grey range. It has been shown that detailed relationships between various mechanical tests, such as transverse-tensile, transverse-Brinell, etc., are only true for one particular set of melting conditions—that is, one particular foundry,—but these relations, while not generally valid, are useful to a foundry for its own purposes, as changes in them show the effect of changes in melting practice. It should be borne in mind that a thick section of cast iron is relatively weaker than a thin section by virtue of the fact that the slower rate of cooling permits the growth of an increased graphite size, and in addition there is what may loosely be described as the effect of grain size to be taken into account. A problem yet to be solved, however, lies in the relationship between these properties and abrasive wear, hardness and machinability, and particularly the relationship of these three properties among themselves.

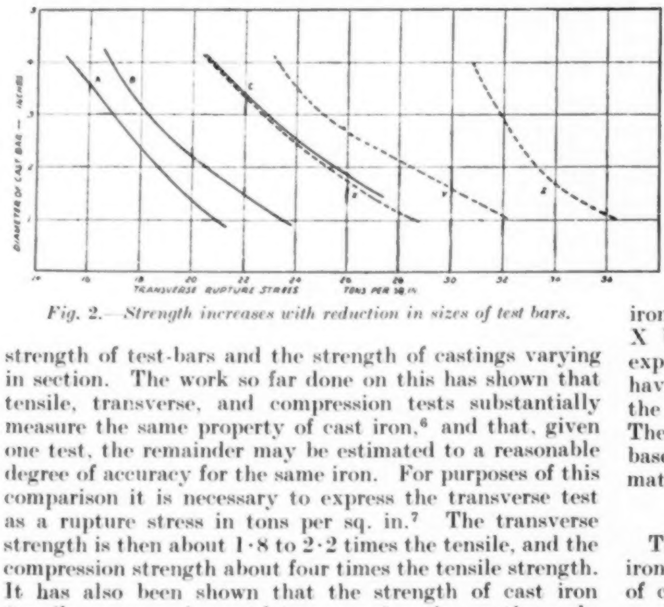


Fig. 2.—Strength increases with reduction in sizes of test bars.

Few founders appreciate the enormous effect on the strength of the casting of the size and distribution of the graphite, or how easily this size and distribution are affected by changes in pig-iron or coke or scrap, and it should be borne in mind that these changes take place even when the material is chemically controlled and composition remains within the usual limits. Analysis is not a complete guide to the properties of grey iron ; structure is equally important.

Fig. 2 shows the way the strength increases as the size of the bar tested diminishes for three remelted pig-irons, A, B, and C, of varying silicon contents. In the same figure are given strengths of three pig-irons of lower total-carbon contents, X, Y, and Z, from which it may be concluded that a diminution of the total carbon tends to push the size-strength curve bodily to the right. The analyses for these irons are given in Table I., and it is interesting to compare the analyses of C and X, shown by the chart to have very similar strengths in the same size of bar.

In Fig. 3, curves A, B, and C refer to three cast irons melted in the same foundry under the same conditions, but from differing mixtures, C being the best quality and A being of ordinary quality. For purposes of comparison, X shows the strength of an inoculated iron suitable to replace C, Y shows the strength of the white iron bars, which were poured from the same metal as X before inoculation took place, and Z shows another experiment on an inoculated iron with a different base, having with the inoculant a ferro-alloy addition to raise the silicon content to 1·7% and the manganese to 0·7%. The analyses given in Table I. on 8x and 8z are of the base metal prior to inoculation. The inoculant does not materially raise the silicon content.

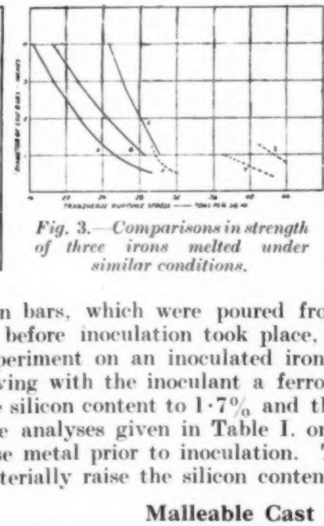


Fig. 3.—Comparisons in strength of three irons melted under similar conditions.

Malleable Cast Iron.

The bulk of the work done by the Association on malleable iron has consisted in an examination of the effect of elements of composition, carbon, silicon, manganese, etc., on the mechanical properties of the annealed whiteheart material.[9 10 11] Incidentally, it may be added that the effect on properties of all the ordinary elements of grey cast iron has been very fully determined, including the effect of some of the better-known additions, such as nickel and chromium, over a range far beyond that used in ordinary practice, several interesting irons of novel properties having been discovered. This work has paved the way for what may be the next main problem in cast metals, and that is the problem of shrinkage and contraction, which is shown in such troubles in practice as porosity, openness of grain, draws, and so on. The question of what test results may be expected from malleable iron depends normally on the test-bar chosen, particularly with whiteheart, and the Association is at present engaged in determining the most suitable size and shape and what thicknesses most appropriately represent particular thicknesses of castings.

The distinction which existed at one time between whiteheart and blackheart is gradually being obliterated, and

the time may not be far distant when it will be necessary to consider malleable iron on its merits entirely from the point of view of mechanical properties, and without regard to a particular process of manufacture concerned.

Recommended Methods of Examination.

One of the difficulties which confronts the Association from time to time arises from differences in analyses reported by different laboratories on the same iron. Where such differences are due to the heterogeneity of the material itself, they cannot be overcome, and, in fact, they are a valuable index to the extent of the heterogeneity. But where they arise from differences in the laboratory methods of analysis, remedial differences in modes of sampling, etc., they form a source of constant friction in the trade between the buyer and seller and the Association, in addition to the report mentioned above on methods of testing moulding sands, has issued recommended methods of sampling and analysis, for pig-iron, white and grey iron, and cast steel, and also including coke, coal dust, blackings, plumbagos, etc. The sands report covers sands and refractories. These two reports, therefore, form a useful basis for internal standardisation in the industry, and the demand for them is indicated by the fact that at present they are both out of print. New editions will be available during the next few months. The Association, of course, is greatly concerned with standardisation of test-pieces, test procedure, and methods, and assists where necessary in the consideration of specifications issued by the British Engineering Standards Association.

Conclusion.

The manner in which the Association is organised is such that the whole of the staff works as a team, and, whoever is charged with the responsibility of presenting a particular report or paper, every member of the staff shares in the work described to a greater or lesser degree. The mode of organisation permits a very high degree of specialisation in its component parts. The Association also works in very close contact with other bodies who are concerned with research work which may interest the industry, particularly with the Iron and Steel Industrial Research Council recently formed by the National Federation of Iron and Steel Manufacturers, and which conducts important investigations into metallurgical coke, and with the other research associations.

The work would also not be possible without the very great willingness invariably shown by members to co-operate in providing facilities in experiment. Also, the Association is greatly indebted to firms engaged in the supply of foundry equipment and materials for the readiness with which they co-operate to the same end. The Council greatly values this co-operation, as it believes that the interests of suppliers of foundry materials and equipment and of makers of castings are identical, in that both need castings of low production cost and high quality, able to maintain the status of the industry and compete with the alternatives which are available.

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The Institute of British Foundrymen.

(*Continued from page* 54.)

from the viewpoint of one who had been intimately concerned with the design and production of motor-cars in this country and the U.S.A., and with more than a nodding acquaintance with American foundry practice. Automobile engineering, he said, is characterised by several features which do not apply to mechanical engineering in general. A motor-car is a mass-production product, representing a great deal of highly-stressed mechanism packed into a very small space ; not only is the product such that it can be made throughout by unskilled labour, but usually it is used by people as unskilled as those who produce it.

Further, in no branch of engineering does a new idea progress from laboratory to practice more rapidly, nor is there a higher standard of manufacturing excellence combined with cheap production. There is probably no detail, be it tyres, wheels, springs, valves, sparking plugs, electrical equipment, brake linings, or any of a myriad others, to which many men may not profitably, and in fact of necessity, devote their whole lives in order that the motor-car may be the ubiquitous instrument of modern civilisation it has now become.

In concluding, Mr. Pomeroy remarked that the British motor industry has passed through its parish pump and local government stages, and is about to become a dominating factor in British Imperial trade. The momentum of prosperity always projects itself across the abyss of trade depression and reveals hitherto unsuspected opportunities for progress on the other side. It is no longer possible, if it ever was, to conduct related industries in water-tight compartments. The problems before the engineer and the foundryman interlock and overlap to the extent that lines of demarcation are impossible, and in these circumstances the freest and frankest interchanges of experience and opinion between the interested trades is not only a counsel of commonsense, but of sound business.

This paper was of a particularly contentious character, and several members endeavoured to show that the really beautiful designs capable of being produced in the foundry were the result of close co-operation between the foundry and drawing-office, while the outrageously complicated castings, referred to by Mr. Pomeroy, were the requirements of the engineer. Several speakers disagreed with the assertion that metallurgical improvements in regard to ferrous castings used in a motor-car had not progressed in keeping with other branches of engineering. The general impression arising from the discussion was that engineers can obtain high-duty ferrous castings providing engineers are willing to pay the extra cost involved in their production. There was, unfortunately, little time in which to discuss the comprehensive review of recent developments in cast iron in Great Britain by Mr. J. G. Pearce, which is given elsewhere in this issue, but comments were made on the balanced cupola.

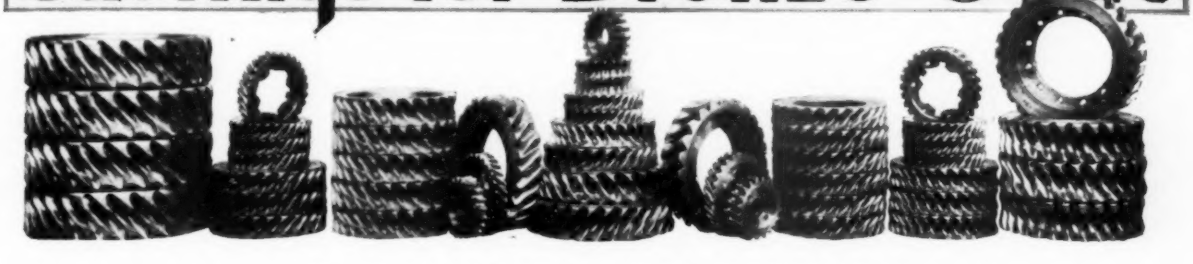
Technical Societies Co-ordinate their Activities.

A further step in the co-ordination of the activities of technical societies has recently been taken by the formation of the Association of Secretaries of Engineering Societies in Glasgow. The membership is representative of 17 associations, comprising the national societies and the Scottish branches of all the important British societies, and the members have the full support of their respective Committees.

One of the objects of the Association is so to arrange the dates of meetings of the constituent societies that there shall be the minimum of interference between the various fixtures. It will also keep its members informed of the activities of the different societies. It is proposed to publish a joint programme of meetings, and to make reciprocal arrangements for attendance at meetings.

The Convener of the Association is Mr. P. W. Thomas, B.Sc. Eng., Secretary of the Institution of Engineers and Shipbuilders in Scotland.

Castings for Bronze Gears



By Francis W. Rowe, B.Sc., M.I.M.M.

Part IV.* The effect of different constituents in bronze compositions.

The Effect of Phosphorus.

As is well known, the primary effect of phosphorus is to secure deoxidation of the bronze. Furthermore, it increases markedly the fluidity of the bronze and generally improves (in quantities up to 0·3 or 0·4%) the casting properties. The phosphorus enters in the bronze almost entirely as copper sulphate Cu_3P, containing 14% by weight of phosphorus.

Whilst copper phosphide is soluble to the extent of nearly 0·5% in pure copper at normal temperatures, it is, to all practical purposes, insoluble in bronze containing 7% and upwards of tin.

In certain conaitions, as little as 0·03% can be detected under the higher powers, and when 0·06 to 0·08% is present this can be detected with great facility. The phosphide is usually associated with the alpha delta eutectoid, but often small isolated patches can be seen. Since it has a characteristic blue colour as against the white of the delta, it can easily be distinguished from it under the higher powers of the microscope, although it is somewhat difficult to record the difference photographically. Fig. 26 shows a typical patch of Cu_3P. When larger quantities of phosphorus are present a definite triple eutectoid is formed with the alpha-delta eutectoid melting at 620° C., and has the appearance shown in Fig. 27.

It has been suggested that the presence of phosphide lowers the tin content of the alpha solid solution, but whilst this is strictly true the effect is not sufficiently marked to be of practical importance. The effect of the phosphide on the physical properties of a bronze is generally the same as the alpha-delta eutectoid. It hardens the bronze, raises the yield-point, reduces the ductility, and decreases the shock strength. The precise differences between Cu_3P and the alpha-delta are, however, such as to render them commercially very important.

First of all, there is the question of hardness. Although the author's work on re-determination of the hardness of the phosphide on the new B.E.S.A. scale, the preliminary work would indicate corroboration of previous determinations—*i.e.*, that the phosphide is somewhat softer than the alpha-delta, so that, beyond the casting advantages accruing from the presence of up to 0·4% phosphorus, there is no advantage in using phosphorus as a hardener.

Anyone doubting the relative brittleness of the two constituents should compare the ordinary 15% phosphor copper of commerce with a small sample of chill-cast 27% tin bronze, these being respectively 100% Cu_3P and 100% $\alpha\delta$. Whilst both are extraordinarily brittle, the phosphide is very definitely more so. The relative embrittling effect of phosphide and alpha-delta was shown in a series of tests given by the author in a paper to the Institute of Metals a few years ago, and reproduced in Table III.

Thus, to secure the best mechanical properties from a bronze, consistent with the desired hardness, the phosphorus should not exceed that quantity called for by foundry requirements—*i.e.*, not more than 0·4%.

There is a temptation to use phosphorus in place of tin as a hardener on account of price. 1% of phosphorus raises the hardness by approximately as much as 2·6% of tin and (even with tin at its present low price) at just about half the cost.

The Effect of Lead.

In bronzes for certain types of bearings, lead is a desirable constituent. Lead is practically completely insoluble in copper and bronze, and thus appears as isolated patches of pure lead varying in size and distribution according to the conditions of solidification. Its main effect is in reducing the yield-point in compression, giving a bronze of more plastic character. The coefficient of friction of the bronze is also reduced, due to softening of the matrix, but the resistance to abrasive wear appears to be decreased.

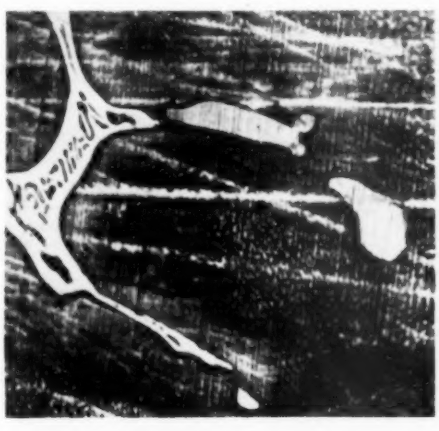


Fig. 26.—Patch of Cu_3P associated with alpha-delta in phosphor bronze. Mag. 800 diams.

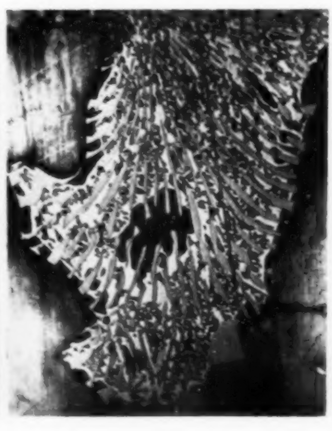


Fig. 27.—Typical patch of Triple Eutectoid of alpha, delta, and copper phosphide. Mag. 800 diams.

It lowers the hardness and tensile strength progressively in amounts above 1%. Thus, since a high-tensile strength and high yield-point in compression are necessary in a gear bronze, lead should not be present in quantities above about 0·5%. Whilst the effect is far from being material or marked, 0·5% lead does seem to have a beneficial effect in amounts of this order, and one or two users definitely specify the addition of this quantity.

* *Continued from May issue, page 28.*

The Effect of Zinc.

The author is rather diffident to express dogmatic opinions on the effect of zinc on gear bronzes, as the subject bristles with complications dependent on the exact service conditions. Zinc, in the quantities usually met with, dissolves in the alpha solid solution, slightly lowering its solubility for tin. It hardens the alpha solution, and thus from the basic standpoint is deleterious as partially impairing the difference in hardness between the two constituents.

TABLE III.

SINGLE BLOW IMPACT TESTS ON BRONZE AND PHOSPHOR-BRONZE, WITH BRINELL HARDNESS DETERMINATIONS.

Bars sand-cast 1 in. square and machined to 20 mm. square.

Three standard B.E.S.A. notches.

No.	Composition.		Ft.-lb. to Fracture.
	Tin.	Phosphorus.	
1	10.3	0.02	65
2	11.65	0.04	53
3	12.33	0.03	48
4	13.08	0.04	41
5	9.26	0.43	42
6	10.43	0.37	38
7	11.87	0.62	24
8	12.92	0.55	21
9	10.03	1.41	14

It certainly reduces the resistance to abrasive wear when present in quantities appreciably above 1%, but raises the yield-point in compression. It would appear better to secure this raising of the yield-point by using more tin, and thus also secure greater, instead of less, resistance to wear, although lowering the shock strength. Very few makers or users of gear bronze permit more than 0·5% zinc, but one well-known bronze founder in this country has used $1\frac{1}{4}$ to $1\frac{1}{2}$% zinc with 13% tin for sand and chill-cast bronze for many years.

The Effect of Nickel.

Due largely to the propaganda work of the producers of nickel, much prominence has been focussed in recent years upon the effect of additions of this element in various alloys, both ferrous and non-ferrous. So far, no really comprehensive study has been made available regarding its effect on bronzes and phosphor bronzes, either as regards physical properties or constitution.

Nickel, in proportions up to 5%, has been tried as addition to bronzes for bearing purposes, both in addition to and replacing part of the tin.

Nickel raises the tensile strength of the bronze and increases the hardness without materially affecting the shock strength. It also, in a similar manner to zinc, increases the yield-point in compression, and in a rather more marked manner. Since also it dissolves in the alpha solid solution, strengthening and hardening it, this fact has to be borne in mind when considering the use of nickel. The resistance to abrasion is increased, but the coefficient of friction is increased slightly, and some of the plasticity of the bronze (which in some types of duty is an essential characteristic) is impaired proportionally to the nickel content. On the other hand, the fatigue limit is raised, and this, combined with the increased resistance to abrasion, may be, for some duties, of paramount importance.

Everything depends on the amount of the other constituents, the method of casting, and the duties and conditions of service. The effect of nickel on the constitution is not yet clear. Where the nickel is above about 1·5%, or the phosphorus above 0·3%, a new phosphide, probably NiP, makes it appearance. This phosphide is very hard—harder than the Cu_3P, and at least equal in hardness to the alpha-delta eutectoid, if not greater.

Beyond the new phosphide constituent, the addition of nickel up to 2% has no apparent effect on the microstructure, the remainder being dissolved in the alpha solid solution. With additions above 3%, the amount of alpha in the eutectoid gradually lessens until at 5% what was the alpha consists of homogeneous patches. Whether these consist of a triple solid solution of tin, copper, and nickel is not yet clear. A typical structure of this character is shown in Fig. 28. The requirements, therefore, of a gear bronze can be thus briefly summarised.

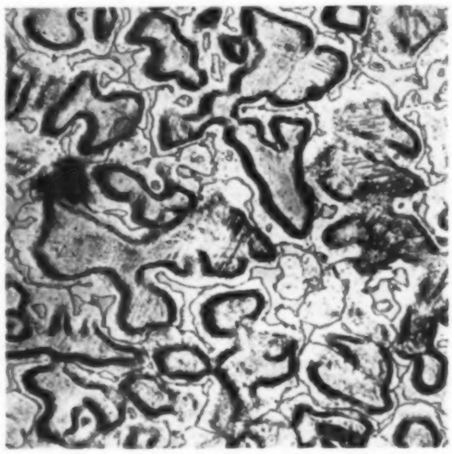


Fig. 28. Typical structure of bronze containing 5% nickel. Mag. 200 diams.

Whatever the composition of the alloy, it will give the best results possible from that composition if cast in such a manner as to give the smallest grain size and highest density. These will also be associated with the maximum tensile strength and hardness, highest load-carrying capacity (fatigue strength) and resistance to abrasion.

Sand castings should never be used except where due to size (either so small or so large): they cannot be cast otherwise. If sand castings are inevitable, due to the size or shape, then the composition and casting conditions must be regulated to give the nearest possible approach to the physical properties attained by other methods.

Chill sand casting is superior to sand casting, but possesses many disadvantages.

Centrifugal casting, when properly conducted, gives the highest physical properties of which a bronze of any composition is capable, and the best results in service. Every physical property is improved, including those of supreme importance—load-carrying capacity and resistance to wear.

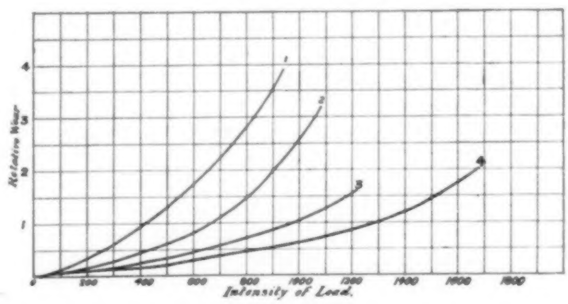


Fig. 29.—Comparative wear and load-carrying capacity of worm wheel bronzes.

The finishes of the curves represent the load at which the bronzes fail.

1. *Admiralty P.B. (Sand cast)*
2. *11·5% Tin Bronze (Sand cast)*
3. *11·5% Tin Bronze (Chill cast)*
4. *Special Bronze (Centrifugally cast)*

Typical comparative figures showing the loads at which various bronzes failed by fatigue under service conditions and stresses, and the comparative amount of wear which took place, are shown in the curves in Fig. 29.

The composition of the bronze may be varied (within the limits given in Part I.) to give the best results, according to the conditions of service where the relative importance of such factors as tensile strength, shock strength, plasticity, resistance to wear, and load-carrying capacity, may vary.

Aluminium Sheet Production

By Robert J. Anderson, D.Sc.

Part VII.—Ingot Pouring Practice.*

Practice employed in pouring aluminium rolling ingots with particular reference to tilting, vertical book moulds.

THE process of pouring aluminium in tilting, vertical book moulds presents several interesting features. In book-mould practice the mould is first tilted up to a nearly horizontal position before the start of pouring; as pouring proceeds it is tilted slowly back so that it assumes a vertical position when filled with metal. The angle of tilt at the beginning of pouring is about five degrees with the horizontal. The pouring ladle is held in a more or less vertical position at the start, and is tilted up as pouring proceeds, assuming an almost horizontal position when the mould is full. Fig. 6 shows three positions of a tilting book mould in the pouring process. With the type of suspension favoured in American practice, the axis of revolution is the supporting bar, which passes through the lug at the top of the hinged edge. With the axis of revolution at the centre of gravity of the mould, as in some designs, the arc traversed by the pouring edge of the mould is substantially greater. This is disadvantageous, especially when the pouring ladle is not affixed to the mould. In Fig. 6 the arrows show the directions of travel in lowering during pouring.

In the operation the pouring ladle is held in position so that the lip is just at the edge of the mould cavity. Then the ladle is tilted up by means of the shank so that the metal flows slowly and evenly down the narrow edge of the cavity. The surface skin on the liquid metal may be pushed back with a skimmer just before the ladle is tilted. However, the skin may be left undisturbed, with the view to preventing further oxidation, the metal being poured beneath it. When the surface of the metal in the mould (still in the original starting position) has risen to within 3 in. to 6 in. of the top, measured on the inclined narrow edge, the mould is then lowered slowly. It is obvious that the mass of metal in the mould before the start of tilting depends on the original angle of tilt. This varies somewhat, depending on the preference of different operators. The flow of metal is continued uninterruptedly, and the mould is simultaneously tilted back until it has attained a vertical position and is filled. Then the pouring ladle is removed, and the mould is fed at the head with liquid metal by means of a hand ladle. Feeding is continued until the piping stops and the ingot is frozen at the head.

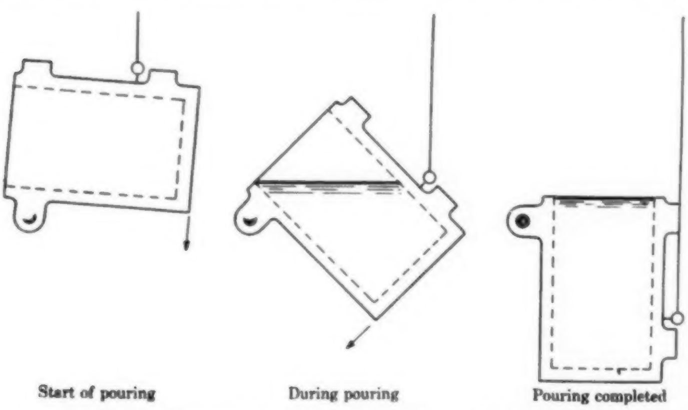


Fig. 6.—Representation of positions of a tilting book mould during pouring.

Book moulds may be tilted (raised and lowered) by chain hoist, air hoist, or electric hoist, when the suspension is of the bar-and-lug type. In some designs—*e.g.*, when the axis of the revolution passes through the mould faces and is situated, say, at the centre of gravity of the mould, the tilting is done by hand lever or hand wheel. Operation by chain hoist has not given satisfactory results, since the descent is prone to be jerky and to cause disturbance of the metal flow and top surface. Raising by chain hoist is unnecessarily laborious. Operation by air hoist has given fairly good results in the hands of skilled pouring crews. However, the best operation is had with electric hoists. In modern designs, which have been developed for handling book moulds, variable speed ranges are incorporated, particularly for the descent. A fast rate of travel is desired for the ascent. With the provision of suitable stops properly adjusted, the distance traversed by the suspension hook of the hoist (and, consequently, by the end of the mould) may be closely regulated. Thus, the operator has merely to push a button, whereupon the mould is pulled up quickly to the correct angle of tilt, further travel being prevented by the kick-off stop. The desired rate of travel in lowering is secured by selection among the speed ranges, the hoist being started in the descent by pushing a button and being stopped, when the mould assumes its vertical position, by an automatic cut-off switch. The use of an automatic electric hoist reduces labour costs at the mould line-up and gives better control of the pouring operation.

Pouring ladles may be handled satisfactorily with chain hoists since the ladle is raised only slightly during the operation, the actual pouring being done largely by tilting with the double-handled end of the shank. Reference has previously been made to the matter of affixing the ladle to the mould. In some plants where insulated cast-iron pots are used for pouring, hooks are provided on the ladle, these hooks fitting over pins in the mould faces. Such arrangement prevents wobble of the ladle, and enables the pouring to be done by one man.

The time required in pouring an ingot in a vertical, tilting book mould varies from about 1 minute to 4 minutes, depending on the size and design of the mould. Rather slow pouring is favoured by most operators. Thus, in one plant where non-tapered moulds are used, the time of pouring for 130-lb. ingots is about 3 minutes. However, in another plant where tapered moulds are employed, the time of pouring for 100-lb. ingots is 1 minute. In both cases, the "time of pouring" means the time consumed in lowering the mould.

Regarding the cooling of moulds by water-spray, the details of practice vary, depending on conditions. In one plant a water spray is provided for each mould face, the spray being made by a perforated pipe situated near the top of the mould. The water is shut off during pouring and heading, but is turned on after removal of the ingot and left running until the mould is again used in its regular turn. At another plant, the moulds are sprayed by stationary perforated pipes, positioned so that the mould comes in line with the spray as it is lowered; here, the moulds are sprayed during pouring and heading, as well as between pours, the water running constantly.

After filling care should be taken in removing the pouring ladle so that the mould is not bumped, thus avoiding any agitation of the metal. The ladle may be held in position, after backing-off the hoist slightly, until the heading is nearly completed.

*Continued from May issue, page 16.

After heading, ingots are allowed to remain in the moulds for 6 to 10 minutes; the time depending on various conditions, including size of ingot, mould temperatures, number of moulds in the line-up, whether ingots are rolled directly from the moulds, and other factors.

Fig. 7 shows the operation of pouring aluminium ingots in book moulds, using a graphite-clay crucible; the mould has assumed the vertical position at the end of the pour. In Fig. 8 a man is seen removing an ingot, the next man is heading up with a hand ladle, and further back will be noticed a mould pulled up and the pouring operation just starting. The fog in the photographs is steam from the cooling water sprays.

In removing ingots from book moulds, the keepers are knocked open, the movable half of the mould is swung over to one side (the revolution being on the back hinges), and the ingot is pulled out with a pair of tongs. The ingot may be dressed by scratch brushing the large faces and chopping off fins (if any). If rolled directly from the moulds, the ingots may be delivered to the hot mill by suitable mechanical conveyer or by small hand buggy. Otherwise they are stacked in piles, preferably on skids, and removed subsequently to the preheating furnace.

The faces of the mould cavity may be swabbed after the ingot is removed. A swab is made by tying a ball of rags on the end of a stick. In the operation the swab is dipped in water and the mould faces are rubbed, this removing any small pieces of metal and preventing accumulation of "fuzz." Swabbing also has some cooling effect.

Labour requirements in ingot pouring vary, depending upon the equipment used and the tonnage required. A furnace tender will tap the furnace, flux the metal, and prepare the ladle ready for pouring. The caster will transport the ladle to the mould. If the ladle is affixed to the mould and an automatic electric hoist is used for lowering, the caster can pour the ingot alone. Otherwise, two or three men may be required. One man is employed on a line-up of 10 moulds for heading and removing ingots. He will assist the caster in fixing the ladle to the mould. Labour costs in pouring can be greatly reduced by the use of proper equipment and good organisation of the casting crew.

Pouring Rates.

Comparatively slow pouring rates are generally used for aluminium-ingot production. Rates considered rather fast for aluminium would be regarded as slow for brass. A sudden delivery, or initial slop, of metal at the start of pouring is highly undesirable in the case of aluminium. In practice, the most satisfactory results appear to be obtained when the pouring is conducted as follows: The initial delivery should be very gentle and slow so that the flow of metal starts without splashing; then the rate may be increased somewhat as the mould fills; finally, as the metal approaches the top of the cavity, the delivery rate should be decreased so that any secondary piping in the centre of the ingot will be fed and the quantity of metal required in feeding the head will be reduced. If the pouring is too fast, secondary piping may occur, and the ingot may tend to be porous since the dissolved gases do not have opportunity to escape. On the other hand, if the pouring is too slow, premature freezing may set in, and dross inclusions may be carried into the ingot.

A proper pouring rate promotes the solidification of the metal in successive layers from the bottom upwards. As above intimated, a slower pouring rate shortens the head pipe in contradistinction to a fast rate which increases it. The amount of piping is, of course, influenced by the pouring temperature and presence of dissolved gases in the metal (*vide* Pouring Temperatures, page 65). Skill in pouring at a uniform rate and then changing to another uniform rate requires long practice. The idea of pouring at specific rates and mechanism for controlling such rates has been embodied in patents by Lummis†, among others.

† U. S. Pat. 1,089,139, March 3, 1914, and 1,143,215, June 15, 1915.

From the point of view of production, a slow pouring rate is distinctly undesirable, and various alterations in mould designs and methods of controlling cooling rates have been tried with the view to speeding-up the operation, but at the same time not injuring the quality of the ingots. One method of doing this entails the use of tapered moulds—*i.e.*, having thicker walls at the bottom than at the top. Another method calls for the use of water-cooled moulds, or increasing the water flow in the case of sprayed moulds.

If an ingot measuring $3\frac{1}{4}$ in. × 14 in. × 24 in., and weighing about 106 lb., is poured in 1 minute, the average pouring rate is about 1·77 lb. of metal per second; also, if a $4\frac{3}{4}$ in. × 12 in. × 24 in. ingot, weighing about 130 lb., is poured in $3\frac{1}{2}$ minutes, the average pouring rate is about 0·62 lb. per second.

In a later article dealing with defects in aluminium sheet, the effect of faulty pouring technique on flaws in the original ingot will be discussed.

Heading Practice.

During the course of pouring the metal starts to freeze, and after the mould has been filled the rate of solidification increases rapidly. As the metal solidifies the volume of

Fig. 7.—End of pouring operation.

the mass decreases. If the liquid metal poured into a vertical, tilting book mould were allowed to solidify uninterruptedly, a deep pipe extending about half-way from the top towards the bottom would form. Such a piped ingot would be useless for rolling unless the entire piped portion was cropped off; also, the mass of metal adjacent to the pipe would be spongy.

In order to prevent piping, which is exceptionally severe in aluminium on account of the high contraction in volume on freezing, additional liquid metal is supplied to the still liquid metal at the head end after the mould has been filled from the pouring ladle. This operation of supplying liquid metal in order to prevent piping is referred to as heading. The heading or feeding is done at such a rate that the top surface of liquid metal remains substantially flat, or rather, bulges up a little, under the action of surface tension. In other words, the heading must keep pace with the rate of sink caused by the contraction. Liquid metal is supplied so long as the piping tendency is noticeable, until finally the whole mass of metal has frozen.

So-called dozzles or hot tops are not ordinarily used in aluminium practice, but the feeding metal is supplied to the head with a small hand ladle (6 in. to 8 in. diameter).

This metal may be scooped up from that remaining in the pouring ladle after filling the mould. In one plant, a supply of metal for heading is maintained in a stationary iron-pot furnace handy to the mould line-up. Heading must be started promptly after the mould has been filled. Skill in heading is acquired only with much practice. The top-fed ingot requires no cropping before rolling, and when properly fed it is necessary to crop only a short piece from the hot-mill slab before proceeding with cold rolling. Even this cropping is often omitted.

Pouring Temperatures.

As is axiomatic in general casting practice, aluminium should be poured at as low a temperature as is consonant with easy running, proper fluidity, and good feeding. What may be the best temperature under given conditions may be too high or too low under some other conditions. The most suitable temperature for use under specific conditions may be determined by the process of "try and see," the final criteria, aside from the operating results at the mould line-up and the ingot structure, being the quality of the finished sheets and the rejections on inspection.

The usual pouring temperature for aluminium and its light alloys in ingot production lies in the range of 700° to 750° C., and the average temperature may be taken as

Fig. 8.—Several operations in ingot production.

730° C. In tonnage work the metal is maintained in the furnace at a temperature sufficiently higher than the desired pouring temperature to compensate for the heat loss in transferring by ladle from the furnace to the mould. In small-scale operations the metal is superheated sufficiently in the furnace, and each ladleful may be cooled to the desired temperature before pouring. Temperature control has been discussed in a previous article of this series.[4]

Piping is, of course, influenced by the pouring temperature and presence of dissolved gases in the metal. Apart from dissolved gases the piping is greater the higher the pouring temperature—less metal being held in a given mould cavity at 800° as compared with 700° C. However, the contraction normal to the change in volume on freezing from a high temperature is interfered with by the evolution of dissolved gases, so that, actually, pouring at some lower temperature causes deeper piping.

A few factors affecting pouring temperatures are here indicated briefly. A higher pouring temperature is required with a lower mould temperature since the metal chills faster in colder moulds. Conversely, a lower pouring temperature may be used with a higher mould temperature. As pointed out previously, a lower pouring temperature, or, more precisely, a lower furnace-maintenance temperature, may be used when insulated ladles are employed as contrasted with non-insulated ladles. When the furnace charge carries much light scrap a higher pouring temperature may be required because of increased viscosity of the metal. Finally, the pouring temperature may be definitely fixed within limits by the necessity for maintaining certain furnace temperatures.[4]

Mould Temperatures.

Aluminium is poured into hot moulds. Actual mould temperatures vary considerably in different plants, and even in the same plant, depending upon conditions and the practice at the line-up. Ingots poured into moulds at room temperature are likely to show surface cracks, or at least tend to crack in the hot break-down operation. Moulds may be preheated with gas burners before starting the pouring operation, or simply by pouring a round of hot metal and allowing the ingots to stand in the moulds for about 10 minutes after freezing. Such ingots are, of course, not headed, but are returned to the melting furnace.

Ingot output is governed not only by the melting capacity, handling equipment, and man power provided, but also by the number of moulds available—referring specifically to conventional moulds. If a few rounds are poured in rapid succession into uncooled moulds, the walls become so hot that they will show a red tinge on a dark day. The freezing of metal is very slow in a mould which is so hot. In practice it is found that a water-sprayed mould can be used once every 30 minutes or more; with more frequent use the mould becomes too hot. Moulds cooled by water circulating in the interior of the faces can be used once every 10 minutes or less. In American practice, production layouts of book moulds are installed with eight or ten moulds to the line-up. The moulds are used in rotation, so that each one is allowed to cool for a certain period of time between pours. Thus, in fast practice, a pouring crew will cast 18,000 to 20,000 lb. of aluminium into 100-lb. ingots (180 to 200 ingots) in 10 hours, using a battery of 10 moulds; each mould will then be used once per 30-minute period (approximately). The temperature of the moulds can be regulated more or less between pours by altering the volume of the water spray. It is advantageous to measure the temperature of the moulds with a surface-contact pyrometer—when the moulds have cooled to the desired temperature the water may be shut off. Obviously, the moulds must be water cooled between pours, since air cooling is not fast enough. A mould temperature of about 300° C. gives satisfactory results at one plant.

After pouring and heading, the ingots may remain in the mould upwards of 10 minutes. At one plant, in rolling 2S directly from the moulds, the ingots are removed when a certain number of minutes have elapsed after heading, thus being cooled to a temperature about 15° C. above the desired hot-rolling temperature.

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* Information on ingot pouring practice will also be found in the papers cited in the bibliographies appended to the two previous articles of this series, viz., V., Rolling Ingots; and VI., Ingot Moulds.

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4 R. J. Anderson, "Aluminium Sheet Production. Part IV.—Melting Practice," *Metallurgia*, vol. 3, No. 15, January, 1931, pp. 97-100.

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6 R. J. Anderson, "Aluminium Sheet Production. Part VI.—Ingot Moulds," *Metallurgia*, vol. 3, No. 17, March, 1931, pp. 173.

In the next article of this series the pretreatment of ingots before hot rolling will be discussed; scalping of alloy ingots and preheating are dealt with.

Reviews of Current Literature.

Secondary Aluminium.

THE collection, handling, treating, melting, and marketing of aluminium scrap, together with wastes and the pig metal obtained from them, has been in operation for nearly twenty years in the United States. Although this practice was in operation prior to the war, there is no doubt that the increased demand during that world-wide conflagration placed the production of secondary aluminium on a more important basis and caused the industry to assume unexpected proportions. In Great Britain the industry was not organised on a basis comparable with that of the United States, nor is it yet accepted with the same openness as prevails in that country, probably because the conservative spirit prevalent in our industries is difficult to overcome ; but, whether the secondary aluminium industry is carried on openly or otherwise, it has developed greatly in all aluminium-consuming countries. The use of secondary aluminium has become a necessity, as price conditions have made it uneconomical to use primary metal entirely. The margin between the cost of aluminium alloy products and primary aluminium is so small that labour costs and metal losses would mean producing at a loss. Substantial saving is made by purchasing secondary or scrap metal, and it is for this economic reason that the secondary aluminium industry exists.

In all metal industries it will be appreciated that scrap has an important marketable value, it being consumed in the factory where it is produced, or it is sold to others capable or willing to make use of it, and aluminium scrap is no exception to this rule. As a matter of fact, aluminium scrap is one of the most valuable in common use. For many years scrap of any kind was looked upon with suspicion, and although a certain lack of confidence still exists in some works, competition has become so keen that prices have left no option but to make the utmost use of scrap in some form or another.

The suspicion in regard to the use of scrap aluminium was not altogether undeserved, but the inability of the user of scrap to adopt proper means for sorting, treating, and melting it was in no small measure responsible for the general dislike to its use expressed by purchasers of articles of which aluminium formed a part. This applies more particularly to scrap purchased from outside sources, and not that which is usually formed in some works and is collected and remelted in the same works. When scrap aluminium is purchased from outside sources it is usually of a mixed character, no attempt having been made to distinguish the different kinds of alloys, and unless proper facilities are available for sorting it, and, after melting, determining its composition, troubles are bound to arise. It was to overcome these difficulties that the secondary aluminium industry was initiated, and which is to-day operated on a very sound basis.

Secondary aluminium is pig metal obtained from remelted scrap or waste aluminium. It is so named to distinguish it from metals derived directly from ores which are known as primary metals. The distinction does not imply that secondary metals are of inferior quality, for metals derived either from ore or from waste material vary in purity and adaptability to use in making certain products.

Raw material for the production of secondary aluminium varies considerably, and is difficult to describe, classify, and grade, particularly in regard to what is termed old scrap, but the proper segregation and classification of manufacturing scrap, which is designated new scrap, is simplified by proper collection at the source. When scrap is collected according to its composition, it is more easily remelted to produce pig metal of known composition, and is therefore of greater value than mixed scrap. So many new aluminium alloys have been developed during the last decade that the sorting and classification of scrap metal has become highly complex and the problems of the secondary remelter have increased.

Some idea of the magnitude of the secondary-aluminium industry is obtained from a recent work on the subject by Dr. R. J. Anderson, and although statistics as to the recovery of secondary aluminium are apparently only available for the United States, it reflects the degree of development that must be in progress in all the aluminium-producing countries. Since 1913 the production of secondary aluminium in the United States has increased about tenfold, and in 1929 amounted to 96,800,000 lb. of a total value of $23,135,200. For the same year the output of primary metal was 198,000,000 lb. Thus, it will be noted that this industry has an importance that has not generally been recognised.

The proper handling and utilisation of scrap aluminium and alloys are matters of broad economic importance, and have direct bearing on the profits made by many companies. More scrap could be used directly or remelted by some consumers if they were aware of the facts regarding it and had access to the necessary metallurgical technique. Unfortunately, there has been comparatively little of value published that would assist in the production and utilisation of secondary aluminium, and the present work has been designed to serve as a text and reference book on the subject. It is a very comprehensive treatise, and the author deals with what has been held as a dark mystery with characteristic candour and the lucid manner in which he discusses and explains all the features embraced by this industry is a clear indication of his knowledge of the subject. The author states that he has brought within a reasonable number of pages a blending of theory, plant operation, and commercial practice, which makes the book of the utmost value not only to aluminium metallurgists, secondary remelters, scrap dealers, and manufacturers who produce scrap, but also to most consumers of aluminium and its alloys, especially foundrymen. While the text is concerned with aluminium, much of what is said applies to scrap metals broadly, and the matter may therefore be found of interest by the general metal industry.

There has been no attempt to make out a case for the use of secondary aluminium in place of primary, or for the use of scrap in place of either. In regard to its utilisation, the problem has been attacked from the point of view of the engineer, whose job demands that he determine and use the most economical materials in producing manufactures of sufficient quality for the purpose intended.

An interesting feature of this book is a selected bibliography at the end of each chapter, together with an author's and subject index at the end of the book. It will undoubtedly be recognised as a classic of its kind, its 563 pages being well illustrated, and possessing a fund of information not available elsewhere.

By Robert J. Anderson, D.Sc. Published by the Sherwood Press, Inc., Cleveland, Ohio, U.S.A. Price, $10·0 post free.

Standard Specification for Wrought Light Aluminium.

A FURTHER specification relating to wrought aluminium alloys for general engineering purposes has recently been published by the British Engineering Standards Association. This relates to heat-treated sheets and strips, and covers the alloy generally known as Y alloy. It is drawn up on parallel lines to the B.S.S. No. 395, which covers the alloy known as Duralumin, with suitably modified test requirements. The chemical composition of the material, the tolerances permissible on the finished sheets and strip, and the tensile strength, proof stress, and elongation are specified. Appended to the specification is a useful memorandum dealing with the preparation and heat-treatment of the alloy.

Copies of the new specification (414-1931) can be obtained from the British Engineering Standards Association, Publications Department, 28, Victoria Street, London, S.W. 1, price 2s. 2d. post free.

Recent Developments in Tools and Equipment.

SAND-BLAST EQUIPMENT.

Automatic Sand and Shot Elevator, Mixer, and Dust Separator.

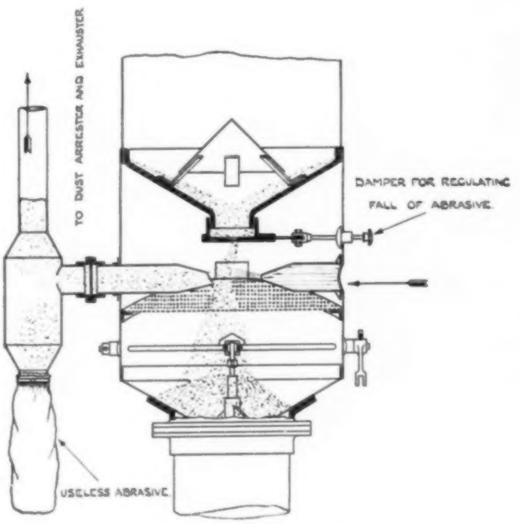
SAND-BLAST equipment is of increasing importance in the procedure required to make castings clean and acceptable to the user. The types of equipment vary, and depend largely upon the size of castings to be cleaned. Of the various types of equipment, the sand-blast room is probably the most convenient to handle a wide range of intricate castings efficiently, speedily, and economically. Improvements in the design of sand-blast apparatus not only effect a saving in fitting costs, but have an appreciable effect in saving time occupied in machining the casting owing to the removal of hard scale, which is so detrimental to the cutting edge of the tools.

In connection with Tilghman's sand-blast plants, a novel apparatus has been incorporated which might be termed the distributing centre of the blast. It consists of a top chamber or cyclone, to which the abrasive and dust is elevated by means of an exhauster—this exhauster also ventilating the operating room or chamber,—an automatic device (provisionally patented) situated below this top chamber for taking away the dust from the abrasive, and a bottom part known as the apparatus or mixer, for storing and mixing the abrasive with the compressed air.

There are no moving parts under the action of the abrasive in these sand-blast room plants, all movement of the chilled shot or sand being accomplished by the exhauster, thus effecting a considerable saving in the cost of renewals. The exhauster can be protected from the action of the spent abrasive and sand by installing a dust arrester.

The provisionally patented automatic device for separating the useless dust from the abrasive material during its circulation is a special feature, and has given the most gratifying results. It should, of course, be borne in mind that when only clean abrasive is allowed to pass to the blast, a larger area is covered on the articles under treatment, thus effecting a considerable saving in power, and providing a much clearer atmosphere for the operator, which in itself is an advantage. The operation of this device is illustrated in Fig. 1.

A sand-blast room plant, incorporating a standard suction arrangement for the elevation of the abrasive material, which includes this patent sieving attachment for the separation of dust, is shown in Fig. 2.



PATENT ABRASIVE SIEVING DEVICE

Fig. 1. Section of patent sieving attachment.

One of the most important considerations in the efficient working of a sand-blast room is its proper lighting. Strange as it may seem, this feature is often overlooked, even where manufacturers have incurred considerable expense in installing modern appliances in every other respect. In such plants the operator must wear some sort of hood or helmet, because of the dust and small particles of abrasive in the air, and this reduces his vision. In the plant under consideration, the floor of the sand-blast room consists of perforated steel plates through which the abrasive passes to hoppers below. These hoppers lead to the collecting pipe through which the abrasive and dust are

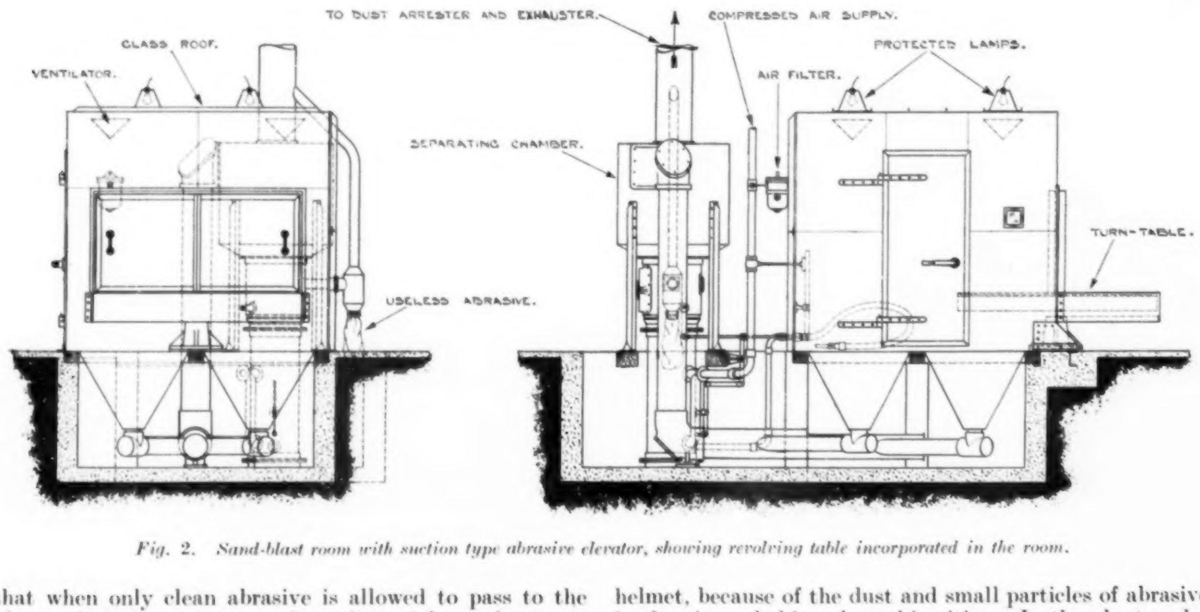


Fig. 2. Sand-blast room with suction type abrasive elevator, showing revolving table incorporated in the room.

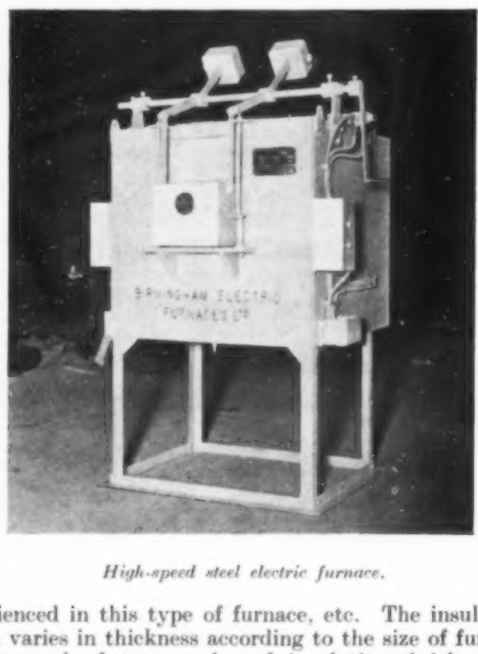
drawn by the exhauster and lifted to the settling chamber of the sand-blast apparatus, from which it passes through the sieving device shown in Fig. 1.

The fact that all the dust created in the sand-blast room is drawn down through the perforated steel floor plates is of importance, as it means that the operator works in a comparatively clear atmosphere, and is easily able to watch the action of the blast on the casting or other article under treatment. To further supplement the visibility of the operator, it should be noted that the roof of the room is of rough wired plate glass, and electric lights, fully protected from flying abrasive material, are readily fitted. The sand-blast operator works under disadvantages with the best equipment, and it is only the simplest form of economy that he should be given adequate light.

Various automatic and semi-automatic sand-blasting methods have been developed in order to speed-up the cleaning of casting by reducing stoppages. An interesting form of an automatic sand-blast machine is shown in Fig. 2. It will be noted that it incorporates a large revolving table, half of which is enclosed in the room, while the remainder is exposed outside. This method enables the cleaning operation to be continuous, the table, being loaded outside the room, revolves, and the operator inside the room is solely responsible for cleaning the castings, thus production can proceed without stoppages for charging.

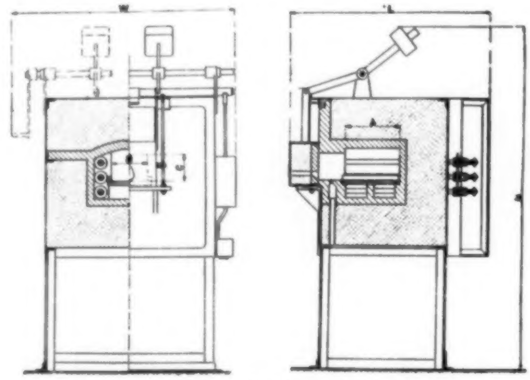
HIGH-SPEED STEEL FURNACES.

ELECTRIC furnaces of new design for operation at temperatures up to 1,350° C., which are specially suitable for the hardening of high-speed steel tools, etc., have recently been constructed by the Birmingham Electric Furnaces, Ltd. These furnaces are built to give efficient and lasting service under workshop conditions, and among their many interesting features are their facilities for rapid and uniform heating and controlled atmosphere. In construction each furnace is robust, the casings being of heavy gauge steel plates and sections. The front frame is of cast iron, with refractory facing around the door opening. The lining consists of highest quality refractory capable of withstanding the severe operating temperatures



High-speed steel electric furnace.

experienced in this type of furnace, etc. The insulation, which varies in thickness according to the size of furnace, is composed of two grades of insulating bricks, each capable of withstanding, without shrinkage, the temperature to which it is subjected. The roof is arched, this form of construction giving the most uniform distribution of heat, with the greatest mechanical strength. The hearth is made of bonded silicon-carbide and is trough-shaped, thus preventing the charge from coming into contact with the heating elements. It can easily be removed and replaced without disturbing the brickwork. The door is of the "raise and lower" type and slides in vertical guides. It is well insulated and faced with special refractory, this facing being continued below the bottom edge of the door,



Sectional elevations of high-speed steel furnace.

so that no warping occurs when the furnace is operated with the door partially open. The door is normally operated by hand, but foot operation can be arranged.

Non-metallic silicon carbide rods—"Globars"—provide the heating elements. These are located in the sides of the furnace, and extend from front to back, as shown in the accompanying sectional elevations. This arrangement gives even distribution of heat, without causing overheating of any of the elements. The life of the rods depends almost entirely on the working temperature, but even under adverse conditions is usually not less than 1,000 hours, and is claimed to be often much longer. When renewal is necessary, the elements can be replaced without disturbing the brickwork. Each element is held between water-cooled terminals, one of which is fixed and the other spring-loaded. Electrical connections to the terminal mountings are located externally, at the sides and back of the furnace. Visible drains are provided into which all the terminals discharge, so that the rate of flow through each can be observed and any irregularity corrected. The water-cooling arrangements are entirely independent of all electrical connections.

All silicon-carbide elements increase in resistance with use. To compensate for the resulting reduction in kw. rating, a transformer equipped with step-up taps is supplied so that the voltage on the rods can be increased and thus useful life prolonged.

The furnaces are heavily rated to give rapid heating and control of the atmosphere, which is so important in the hardening of high-speed steel tools, and is an interesting feature. Ideal conditions are claimed to be provided by a still, neutral, or slightly reducing atmosphere, so that the steel being heated is neither carburised nor decarburised. Such conditions are obtained by admitting semi-burnt gases through a slit extending across the front of the hearth which effectively screens the door opening against the entrance of air. This prevents scaling or oxidation of the work, and, at the same time, makes it possible to operate the furnace with the door open. The temperature-control equipment may be automatic or by hand, according to requirements.

Furnaces operated by automatic control have distinct advantages in giving consistently uniform results with a minimum of attention and at the lowest cost of operation. Such equipment consists of a magnetic contactor switch and a regulating pyrometer (calibrated from 0/1,400° C.), actuated by a Pt./Pt.Rh. thermo-couple. This pyrometer, which may be either of the indicating or recording type, is mounted on an instrument panel, together with red and green indicating lamps, control fuses, etc. A time clock

to switch the furnace on or off at any predetermined time, can be fitted if desired.

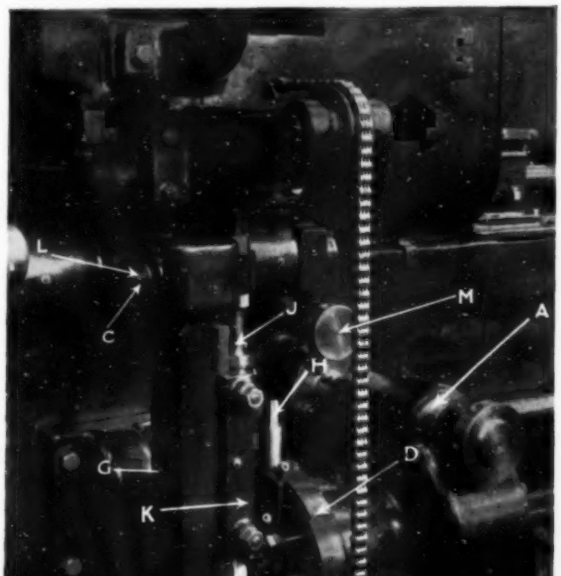
In cases where close control of temperature is not of outstanding importance an alternative is offered in which the transformer is fitted with step-down taps controlled by a hand-operated tapping switch, in addition to the step-up taps. This method, although inferior to automatic control, is claimed to be far superior to control by means of an "ON" or "OFF" switch, or a variable rheostat, the former giving a widely fluctuating temperature, and the latter being extremely wasteful.

These furnaces are constructed in four standard sizes, the specifications of which are given in the following table, the dimensional letters being indicated in the sectional illustrations.

Model.	Internal Dimensions.			Overall Dimensions.						Rating.
	Length. A	Width. B	Height. C	Length. L		Width. W		Height. H		Kw.
	In.	In.	In.	Ft.	In.	Ft.	In.	Ft.	In.	
H.S.1	12	6	4	4	0	5	0	6	3	14
H.S.2	12	8	6	4	0	5	3	6	6	20
H.S.3	16	8	6	4	3	5	3	6	6	25
H.S.4	24	12	8	5	0	6	0	6	6	42

SPECIAL CAMBERING MECHANISM FOR LARGE PLAIN GRINDING MACHINES.

THE accompanying illustration shows a cambering mechanism which has been designed for application to the larger sizes of the plain grinding machines manufactured by the Churchill Machine Tool Co., Ltd. It should be



Cambering device for large plain grinding machines.

noted that no camber bar is used, the motion for operating the mechanism being derived from the bull wheel shaft of the traverse mechanism. In the worm drive at A, the worm-wheel is connected to the crank disc D, to which only a partial rotary motion is transmitted even on full traverse strokes. The throw of the crankpin E is varied by the adjusting screw H, and when in any position other than dead centre, causes the bar G to rise and fall owing to the fact that the crankpin is in contact with the slide K, which is connected through the screw J to the pin L, which passes through the end of the lever C. The latter has its fulcrum against the side of the bed and a short arm behind the adjusting screw J which connects by means of a thrust pin to the rear end of the wheel-head slide B. The front of the latter is mounted on a knife edge about which the whole of the wheelhead is rocked by the cambering mechanism. The adjusting screw J and slide K are included so that the movement of the crankpin can be compensated for. Bar G is connected to the bed at its lower end by the link F which has the same length of arm as the lever C, so that the bar moves with parallel motion in a vertical plane. The screw M is provided so that all parts of the mechanism excepting the lever can be relieved of the load of the wheelhead when not using the cambering mechanism. For concave cambers the crankpin is placed above the centre line of the crank disc, and for convex cambers below the centre line. Outstanding features of this mechanism are compactness, minimum of moving parts, absence of camber bar, wide range of adjustment, producing a true curve and no reversal of stresses in the mechanism throughout the full length of the roll.

This new mechanism does not take the place of the standard cambering device as fitted to the TWS, TWR, FR, and BA models manufactured by this firm, but will be supplied only where a large plain grinding machine with cambering mechanism is indicated as preferable to one of the standard roll grinding machines.

General Meeting of the German Bunsen Society.

THIS year's general meeting of the German Bunsen Society in Vienna was not only an event of scientific importance, but also a vigorous demonstration in favour of co-operation between Germany and Austria, which, if freed from tariff barriers, could work together in the greatest harmony. In the opening session, which was introduced by a speech of the President Miklas, this point of view was especially forcibly expressed as being particularly important with reference to the sphere of physical chemistry, with its combinations of theory and practice.

This year the discussion centred round the problems of metallurgy, with particular reference to light metals. The first chairman of the Bunsen Society, Direktor Dr. Specketer, of Frankfurt-Griesheim, emphasised the increasing importance of aluminium, magnesium, and their alloys. He showed in a few words how the aluminium production of the world had risen in the post-war period, and pointed out that in all transport operations the desire to reduce ballast leads to the use of aluminium and its alloys with specific weights only about one-third that of iron. Similarly, the other papers dealt with various metallurgical problems, and that of Professor Tammann, of Göttingen, the well-known authority on metallurgical problems, who celebrated his 70th birthday during the meeting, was especially well received. The Professor of Theoretical Physics at the Technical High School in Berlin, R. Becker, showed in his concluding lecture that it is possible, by means of wave mechanics and quantum mechanics, to explain certain electric and magnetic properties of metals which have so far appeared contradictory, and he was able, thanks to his lucid exposition, to throw open this very difficult and abstract field of thought to a very wide public.

Although the programme included sixty individual lectures, provision was also made for the entertainment of the participants. A great banquet was held in the banqueting hall of the Hofburg, at which visitors were able to meet and the reception by the Ministers of Education, of Trade, and of Transport, introduced them to the apartments of the famous Schloss Schönbrunn.

The British Non-ferrous Metals Research Association.

THE British Non-Ferrous Metals Research Association, which has established new offices and laboratories in London, is one of several technical organisations which have moved their headquarters from the Midlands to the City. The Institution of Mechanical Engineers and the Institute of Metals both started life in Birmingham, and later moved to London, which is the centre of a rapidly growing industrial area. The opening by Lord Rutherford of the new headquarters on June 8 marks a very important point in the history of the Association's activities.

Incorporated in 1920, with the object of providing a co-operative metal research organisation under the Department of Scientific and Industrial Research, the British Non-Ferrous Metals Research Association consisted of a small body of keen representatives of the industry, who were prepared to carry out prolonged researches which individual firms could not undertake. Although progress was at first slow, after 1922 the number of members and contributions increased steadily until the report for 1930 showed that the income and subscriptions, together with the Government grant, totalled £24,900.

The "application of science to industry" is the Association's ultimate objective. Many urgent industrial problems may be, and indeed have been solved by the introduction of scientific principles, and while carrying out some exceedingly valuable investigations, the Association has completed ten years of "training" in the right method of affording its services to industry. Perhaps the most important researches have been those on the atmospheric corrosion and tarnishing of metals, and the study of the effect of impurities on copper, both of which were started early in the life of the Association and have yielded results far exceeding all expectations. In addition, members of the Association have carried out investigations on lead alloys, aluminium and aluminium alloys, copper, tin, brass, zinc, nickel, gases in metals, annealing furnace practice, and on other subjects connected with all branches of the metal industry.

Modern industry calls for the organisation of technical intelligence services, but the need for such services was not often recognised until recent years. The Association, however, did recognise this, and early provision was made for the establishment of a Library and Information Bureau. This service has grown tremendously, there now being more than 8,000 books and pamphlets in the Library, and an experienced staff, surveying all technical literature in circulation. A quarterly bulletin is issued to members, and information circulars are sent out, on occasion, to draw attention to news items of special interest, while every assistance is given to members to solve technical problems which may be encountered.

A fairly new feature of the organisation is a Development Section formed to bridge the gap between the experiment and its application in industry. The idea of forming such a section was first clearly reviewed at the Research Workers' Conference at Oxford, in January, 1927, and since then considerable progress has been made in this respect. There is, however, some difficulty in finding and training staff with the right combination of imagination, tact, technical knowledge, and ability to explain things clearly and simply. Among recent activities of this section have been the organisation of an interesting Exhibition Room and of regular practical demonstrations.

As regards the new laboratories at the Regnart Buildings, Euston Street, N.W. 1, they are to be considered merely as a preliminary home for the Association until further developments are possible. The building consists of a basement and three floors, each of about 2,500 sq. ft. floor space. The basement is given up to heavy machinery, such as mechanical testing machines, a 100-kw. electric motor generator set, and equipment for casting, annealing, and machining. On the ground floor are the offices and library (for which the Carnegie United Kingdom Trustees have given a grant of £800 for the purchase of books), and on the first floor is the Development Section. The research laboratory is on the top floor.

An interesting addition to the Mechanical Testing Section is a specially designed "slow-tensile" testing machine for measuring the creep of metals at high temperature. Previously, tests to ascertain the rate of distortion and behaviour of an alloy at high temperatures took several months, and in some cases even a year. This new machine will carry out in eight hours the equivalent of a year's testing by the old methods.

A small converted factory is not an impressive home for an important scientific body, but this new move means that a stage has been reached at which far greater opportunities are offered for improved service than have been offered in any earlier period of the Association's history.

Protecting Aluminium.

IN spite of the present industrial depression there seems to be an ever-widening field for aluminium and its alloys in all branches of industry. This is largely due to its adaptability to a wide range of uses, and also to the fact that scientific investigations have been concentrated on overcoming the difficulties formerly associated with this metal and its alloys. On the chart in this issue is given information of value in varying the surfaces of aluminium to provide for decoration, protection from chemical, physical, and mechanical action, etc. Protection probably offers the biggest problem to surface treatment of aluminium, whose characteristic properties are such as to make many of the usual methods either difficult or impossible to apply. With regard to protection from mechanical injury, from the point of view of surface treatment, this is largely confined to reduction of frictional wear. In this connection two interesting examples are the use of zinc plating to prevent aluminium parts from seizing, and the recent introduction of a soft rubber surface coating to reduce abrasion. Protection from physical injury is again from the point of view of surface treatment limited in practice to providing a surface relatively indifferent to temperature changes. For high-temperature resistance the oxidation processes provide a satisfactory solution for aluminium. The question of protection from chemical effect, or corrosion, is by far the greatest problem with which protective surface treatment is called upon to deal.

Corrosive agents may be divided into two types: Natural corrosive agents—that is, those commonly met with in nature—the atmosphere, moisture, sea-water, etc.; and industrial corrosive agents, met with by metals in industrial applications. In the latter case the conditions of corrosion may be said to be stable; in the former case the conditions are by no means constant, and the surface treatment has to be capable of responding to the differing conditions. The first essential of any surface coating from the point of view of chemical protection is that it should be a continuous envelope, sealing completely the metal which it protects; the corrosion attack is then limited to the material of the coating, and can, since the material can be specially chosen to be inert for the particular conditions, be reduced to a minimum. If the coating is not a completely enveloping surface—that is to say, if it is porous—the corrosive effect will depend on whether the coating is a conductor electrically. If it is not, the rate of corrosion of the basis metal is determined by the rate of access of the corrosive agent; if it is a conductor, electro-chemical action comes into play, and the character and intensity of corrosion effect depend on four factors: (1) The relative solution pressure of the basis and coating metals; (2) the nature of the electrolyte—in "natural" corrosion moisture atmospheric or NaCl (sea-water); (3) the nature of the anodic and cathodic corrosion products; and (4) the rate of access of oxygen. A porous coating may, instead of reducing corrosion, very greatly increase it. The second necessary factor for a protective coating is that it must have no internal imperfections which might give rise to weakness; for example, it must not contain traces of a bath liquor, nor be internally stressed.

Business Notes and News

An Engineering Feat.

An interesting achievement has been completed at the Rockingham Collery, Hoyland Common, of Messrs. Newton Chambers and Co., Ltd. For many years the No. 2 shaft has been served by a wooden headgear, but owing to recent "speeding-up" at this colliery it was considered time to replace this structure with a more modern erection. Arrangements were made to carry out the alterations during the Whitsuntide holidays, and work was therefore started on May 22 in the afternoon. When both cages had been lowered to the bottom and the winding ropes taken up, landing beams were thrown across the shaft at a lower surface, and eight steel guides were clamped to the beams and then lowered from the pit headgear. The two 4½-ton winding pulleys were then lowered to the ground level. Dismantling the wooden headgear was then begun, and by 9 a.m. on Monday the whole structure was down and cleared away. The new steel headgear, 60 ft. high and weighing over 60 tons, was completed on Sunday, May 31, and the shaft was working at full speed the following morning. The new headgear was constructed in the works of the firm at Thorncliffe, near Sheffield.

New All-Electric Passenger Ship.

An interesting development in marine engineering was demonstrated recently on the Clyde, where a new all-electric vessel was introduced to the notice of a party of 150 ship-owners, shipbuilders, and engineers. This vessel, named *Lochfine*, successfully completed her trials at the end of May. She is a small passenger vessel built for service on the West Coast of Scotland, and her distinguishing feature is a system of control and propulsion whereby the two 1,000-h.p. heavy-fuel oil engines are directly controlled from the bridge, from either side. The advantages in manœuvring thus gained are very considerable, especially in restricted waterways. The engines, which are fitted with superchargers, were supplied by Messrs. Davey Paxman and Co., Ltd., Colchester; while the whole of the electrical gear was supplied by Messrs. Metropolitan-Vickers Electrical Co., Ltd., Trafford Park, Manchester.

Copper Production within the Empire.

Considerable increase in the production of copper within the British Empire is foretold. Of the great potential producers in the Empire the Northern Rhodesian copper field seems to be by far the most important, and judging from recent reports its discovery may have nearly as much influence as the discovery of the Transvaal gold fields. These reports are from reliable authorities, and it has been estimated that by 1934 the groups operating the mines will be able to produce an annual supply of 300,000 tons of refined copper. With this in view, several important developments are being undertaken, and it is hoped to keep the industry within the Empire, and to give it an established and independent position. The various concerns at present interested in the Rhodesian field have, according to Mr. W. Pellew-Harvey, president of the Institution of Mining and Metallurgy, agreed to refine their copper in this country.

Pease and Partners, Ltd.

Presiding at meetings of the 5% debenture stockholders, and of the unsecured creditors of Messrs. Pease and Partners, Ltd., on May 28, Sir Gilbert Garnsey outlined the scheme of arrangement whereby the company intended to deal with the present situation. Briefly, the scheme, as it affects the 5% debenture stockholders, is to obtain a moratorium for 3½ years in regard to the payment of the interest and sinking fund in respect of the 5% stock, except in so far as such interest, etc., can be paid out of the company's profits each year. As it affects the unsecured creditors, the scheme's purpose is to obtain 3½ years' moratorium for the payment of their claims, except the first £250 of the amount owing, which will be paid to each creditor in the ordinary course of business. In addition, the company are entitled to raise additional capital by an issue of prior mortgage debentures, or debenture stock, secured by the first mortgage on Thorne Colliery, to an amount not exceeding £400,000. The meetings of the debenture stockholders and of the unsecured creditors were held separately, and at each the scheme was approved, subject to the sanction of the court.

Obsolete North-East Coast Shipyards.

Never, it is thought, has the shipbuilding industry been so acutely depressed on the North-East Coast as it is at present; but fresh developments are taking place in respect of the closing of shipyards which are now regarded as redundant. It has been announced that negotiations have been begun for the acquisition by National Shipbuilders' Security, Ltd., of the Hebburn shipyard, owned by Messrs. Dalglish and Renwick. This yard, which was built about two years after the war, has never been used, owing to the industrial depression, and efforts have recently been made to dispose of the undertaking. The National Shipbuilders' Security, Ltd., was incorporated on February 27, 1930, with the object of assisting the shipbuilding industry by the purchase of redundant and obsolete shipyards; the dismantling and disposal of their contents; and the re-sale of sites under restrictions against further use for shipbuilding. Among its purchases have been the Dalmuir yard of Messrs. William Beardmore and Co., Ltd., Glasgow, and the yards of the Ardrossan Dockyard, Ltd., Napier and Miller, Ltd., and Old Kirkpatrick and John Chambers, Ltd., Lowestoft.

Darlington Forge Moratorium.

At a meeting of 6% debenture holders of the Darlington Forge, Ltd., at Darlington, on June 2, it was agreed to adopt the scheme of arrangement regarding the payment of interest on their holdings. This scheme, which was formulated by a committee of directors of the company and a Debenture Holders' Committee, was similar to one previously proposed by the company, except that it did not authorise the cancellation of interest not paid to the debenture holders during the three years' moratorium period, but preserved the full rights of the debenture holders to payment of any interest arrears out of future profits of the company before any dividend was paid to the preference or ordinary shareholders. It also provided for simple interest at the rate of 5% per annum to be paid on any arrears not paid by September 30, 1936.

Bulk Flotation of Gold.

Bulk flotation as applied at the Spring Hill concentrator of the Montana Mines Corporation, near Helena, Montana, is described by L. A. Grant in an information circular, No. 6411, recently issued by the United States Bureau of Mines, Department of Commerce. The ore contains gold as the valuable metal, associated with pyrite, arsenopyrite, and bismuth, as well as in the native state. Barren pyrrhotite is abundant in the gangue. Poor results were obtained with cyanidation because of fouling of solutions by the arsenic and antimony in the ore. Bulk flotation has been practised since May, 1929.

Run-of-mine ore is put through a crushing plant consisting of jaw crushers, a cone crusher, grizzlies, screens, and conveying apparatus, being delivered at about ½ in. size to the mill storage bin at an average crushing cost of \$0·222 per ton. Grinding is done in two conical ball mills in closed circuit, with two overhead 4 ft. by 14 ft. classifiers. Ball-mill loads are composed of five parts circulating load to one part new feed, and contain 50 to 60% solids. Ball consumption is 1·3 lb. per ton ground. A screen analysis of ball mill and classifier feeds and discharges is given by the author. Overflow from the classifiers goes direct to flotation in two machines. Each machine makes a concentrate, which is filtered by a 4-ft. two-disc filter, and a tailing, which is sent to a tailings dam after partial dewatering in a 35-ft. by 10-ft. thickener.

The ratio of concentration is about 12 into 1, the concentrates carrying 3·27 oz. of gold. The principal flotation reagents used are pine oil, potassium ethyl xanthate, Aerofloat No. 25, and copper sulphate. Analysis of concentrates and screen-assay analysis of heads and tailings are given. Gold recovery ranges from 80 to 87%; finer grinding would increase recovery, but only at excessive cost. Head assays have averaged \$6·46, with \$1·22 in the tailings. Costs as well as metallurgical data are tabulated. The total milling cost on 40,930 tons of ore from July, 1929, to April, 1930, was \$1·007 per ton of ore concentrated.

Furnaces to be Extinguished.

Further evidence of the depressed conditions in the iron and steel trade is offered by the recent announcement that Messrs. S. Tyzack and Co., the Wearside iron and steel firm, have decided to extinguish their furnaces on the completion of the contracts at present in hand. As the firm has been working at half pressure for a considerable time only some 200 workmen will be affected.

Business Notes and News—continued.

Steel Firm's Report.

A comparison of the annual report of the Park Gate Iron and Steel Co. for the year ending March, 1931, with that for the year ending March, 1930, gives remarkable evidence of the extent to which the steel trade has declined during the past twelve months. During the year ending March, 1930, the company had a record output of steel ingots, and the profit was such that not only was a debit of £37,772 extinguished, but a further small amount was left to be carried forward. For the period ending last March, however, the output of steel ingots was only 72% of that of the previous year, and the net profit recorded is only £8,209, which is to be carried forward. The directors explain that the trade depression and severe competition reduced the orders, and also that selling prices of finished steel have fallen faster than those of raw materials. In view of the year's trade conditions, they consider that these results are satisfactory, and justify recent expenditure on works improvements and additions.

Stainless Steels.

While trade in almost all its branches seems to be at its lowest ebb, it is interesting to hear that, though hit by the depression, the stainless and corrosion-resisting steel industry is still cheerful. It has not been hit to anything like the same extent as many other industries, and, at the same time, the applications of these steels are ever growing in number, so that future prospects are good. Among recent stainless steel commissions carried out was an interesting piece of work for the Continent, executed by Brown, Bayley's Steelworks, Ltd. This was the production of an absorption column for chemical plant, consisting of a riveted cylinder 41 ft. high and 5 ft. 6 in. in diameter, tested to a pressure of 176 lb. The same firm has recently supplied to a Lancashire concern a set of stainless steel, steam-jacketed 40-gal. pans.

The South Wales Tin-plate Corporation.

Following the announcement that nine companies have decided to withdraw from the South Wales Tin-plate Corporation, there has been much speculation as to whether this move will have any effect on the agreement with America. It appears that it will have no effect, as the period originally fixed for the operation of the agreement comes to an end on September 30 next. Negotiations have already been started with a view to renewing it. It has been officially stated that those members of the Corporation who are withdrawing have decided to sell their shares and to make other plans for the selling of their tin-plates. The only reason for their action is the low demand for tin-plates. Workers at the Yniscedwyn Tin Works, Ystradgynlais, are working under notice, while there has been no work recently at Gurnos Tin Works or at Ystalyfera Tin Works. Subject to the acceptance by the men of certain conditions, it is possible that Baldwin's Eagle Tin-plate Works will be reopened about the middle of next month. These works have been closed down for the last three months. The Llansamlet Works of the National Smelting Co. are ceasing production, owing to the continued low price of spelter. Some 300 men who have for some time been sharing the available work will be affected.

Barrow Haematite Steel Co., Ltd.

Meetings of all security holders and shareholders of the Barrow Hæmatite Steel Co., Ltd., were held recently to discuss the scheme outlined in a circular letter. It appears that since the original scheme of reorganisation of the company's financial structure was sanctioned by the High Court of Justice in January last, the world trade depression and the general lack of confidence in business have made it impossible to arrange the new financial measures detailed in the original scheme. A new plan has, therefore, been drawn up by the directors of the company, and it was to discuss this plan, and to obtain the shareholders' agreement to an extension of the time fixed within which to provide the new money, that the meetings were called. It was explained that the company had been able to hold its own and meet all current trading expenses since the original scheme was submitted, and that the directors believed that if the date for raising the new money was extended it would be possible to protect and carry on the business until the fresh capital could be raised. The new plan was approved by very large majorities at all the separate meetings.

Four Destroyers to be built for Portuguese Navy.

A contract has just recently been signed between the Portuguese Minister of Marine and Messrs. Yarrow and Co., Ltd., shipbuilders at Glasgow and London, for the construction of a flotilla of four destroyers, forming part of the new Naval programme. The first instalment of £45,000, we understand, has been paid.

Portugal's decision to build a new navy was made last year, when four British naval experts went to Lisbon to confer with the Portuguese naval authorities. Tenders for the new warship were invited from British, French, and Italian shipyards, and Messrs. Yarrow and Co. are to be congratulated on their success.

A Welcome Order for Refractory Materials.

The General Refractories, Ltd. has informed us that it has received an export order of unusually large dimensions for refractory materials—probably the largest of its kind that has come to Sheffield within recent years. The execution of the order, we understand, will occupy the entire resources of one of the company's firebrick works for the next two or three months, and its receipt necessitates also the re-opening of another brickworks which has been closed down.

Appointments.

We have been informed that Mr. W. R. Barclay, O.B.E., who for some years has occupied the position of managing director of Messrs. Henry Wiggin and Co., Ltd., has been appointed consulting metallurgist to the Mond Nickel Co., Ltd., with headquarters in London. Mr. A. P. Hague, who is the general manager of the company's Clydach refinery, will succeed Mr. Barclay as general manager, and, at the same time, will continue as general manager at Clydach.

Mr. E. W. Asbury, who has for many years managed the sales department of Henry Wiggin and Co., Ltd., with headquarters at Birmingham, will, at the beginning of June, move to the offices of the Mond Nickel Co., Ltd., at Imperial Chemical House, Millbank, London, where he will continue in charge of the sales business of Henry Wiggin and Co.

The above changes, together with the appointment of the Mond Nickel Co. as sole director and manager of Henry Wiggin and Co., in place of the present board, and the transfer of the registered office to London, are being carried out with a view to effecting closer collaboration between the various interests of the Mond Nickel Co. Mr. D. Owen Evans, delegate director of the Mond Nickel Co., will assume the same position with regard to Henry Wiggin and Co.

It is announced that Mr. Arthur Andrews has been appointed chairman of Messrs. Burton, Griffiths and Co., Ltd., after having rejoined the firm as managing director in 1929, with a view to effecting a complete reorganisation. We understand that upon this being brought to a successful conclusion, he asked to be relieved of the heavy detailed work inevitably connected with the managing directorship of such a firm. His colleagues reluctantly conceded his request, but sought other means whereby they could retain the use of his valuable knowledge of the engineering industry. With this end in view, Mr. Andrews was asked to accept the position of chairman of the company.

The active control of the business is vested in Mr. F. W. Turrell, who is also managing director of the firm's associated company, Messrs. B.S.A. Tools, Ltd. Mr. Turrell will be assisted by Mr. E. C. Farrell, who is taking up the position of sales director of Messrs. Burton, Griffiths and Co., Ltd.

Personal.

Mr. Colin Presswood, B.A., F.G.S., who recently resigned from the position of technical manager to General Refractories, Ltd., is now acting as geologist and consultant. He has been engaged to assist in the sale of "Kniepert" chequers and "Magnesidon" bricks.

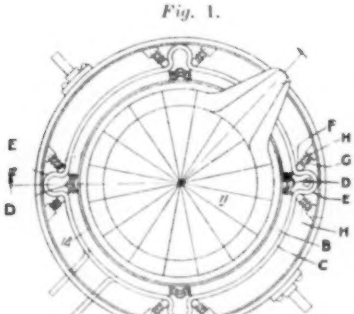
Some Recent Inventions.

INDUCTION FURNACE IMPROVEMENTS.

With induction furnaces of the surrounded-pool type, and of relatively large size, it is highly desirable if not actually necessary, that close operative engagement be maintained between the energising coil surrounding the crucible and the crucible itself in order that the interlinkage of the lines of force generated by the current in the energising coil with the material in the crucible shall be a maximum.

The accompanying illustrations show a method whereby this object is attained. In this device some or all of the turns of the energising coil have major portions extending through a predetermined path in close engagement with the outside periphery of the crucible, and at least one relatively short portion bowed or deformed out of the normal path of the turn. This latter part of the energising coil is preferably of greater resiliency than the major portion of the turn. A number of resilient supporting or pressing means may engage these short portions to assist in maintaining the major portions of the turns in close operative engagement with the outside of the crucible.

Fig. 1.



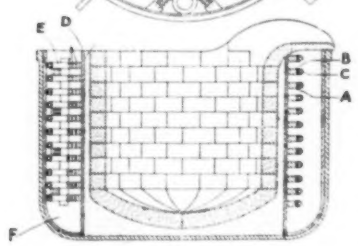


Fig. 2.

The plan and sectional elevation shown in Figs. 1 and 2, embody this improvement. The crucible may be a properly shaped mass of refractory material or built to shape with suitable bricks ; it is cased and insulated with sand to conserve the heat. A tubular shroud of electrical insulating material is located around the crucible in order to reduce the amount of sand otherwise necessary.

An energising coil A is provided around the crucible and embodies a solid portion B for carrying an electric current, and a tubular portion C for carrying a cooling fluid. As shown in Fig. 2 the tubular portion C is separate from, or is brazed or otherwise secured to the solid portion B. The solid portion B is made in arcuate sections, shown as being four in number in Fig. 1, connections between the adjacent ends of the sections of the conductor B being effected by resilient bowed strips D, the ends of which are interfitted with the ends of the sections of the conductor B, to which they are brazed or otherwise secured. The tubular member C is provided with bowed-out or deformed portions E, which extend radially outward from the crucible or radially relative to the axis of the crucible and of the coil.

Auxiliary resilient supporting and clamping means are provided and include a vertically extending bar F having a number of laterally extending integral lugs G, springs H being fitted over these respective lugs, one end of each spring engaging the bar F and the other end engaging a lug integral with the casing. The lugs G and the springs H extend tangentially of the coil A and assist the inherent resiliency of the portions D and E of the coil to maintain the conductor in close operative engagement with the crucible and mor particularly with the casing.

347,986. The Associated Electrical Industries, Ltd., Bush House, Aldwych, London, W.C., Assignees of P. H. Brace, Forest Hills, Pennsylvania, U.S.A., patentee. A. S. Cachemaille, Agent, Norfolk Street, Strand. London, W.C. Accepted, May 7, 1931.

PNEUMATIC PERCUSSION TOOLS.

Pneumatic tools have been improved and developed to such an extent during recent years that they are now regarded as essential appliances for a wide range of operations. Not the least useful are those that have been designed as percussion tools. In these tools the action should be free from recoil, the design and construction should be perfect yet simple, and the workmanship such as will guarantee their reliability and durability in service, and, useful as these tools undoubtedly are, further improvements have been developed to increase the significance of these features and to widen their scope. Recently a novel design has been introduced which will readily find application. The usual type of cylinder head for these tools is fitted with holding-down nuts which have a tendency to loosen as a result of vibration. In the new design, however, these have been dispensed with, the object being to provide a tool having a smooth contour and free from projections. In addition, the head has been designed so that it is at right angles to the handle, reducing its length and enabling it to be inserted into more restricted positions than the usual form of pneumatic percussion tools.

As will be seen from the accompanying illustrations, which show the improved design applied to a scaling hammer, the tool-head comprises a single block bored from one end only to form the cylinder. The piston, it will be noted, is limited in its outward travel by a movable collar. This collar may be made to fit into an enlarged part of the bore of the tool-head, a groove being formed to receive a spring split-ring which retains the collar in position, or, alternatively, the collar may be screwed in position.

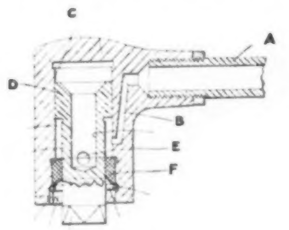


Fig. 1.

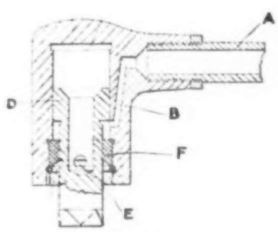


Fig. 2.

In operating the tool, the compressed air passes along the tubular handle A, Figs. 1 and 2, through the passages B into the lower end of the cylinder C, with the result that the piston D is forced inwards until the outlet orifice E begins to move clear of the collar F. The air then flows through the orifice E to the other side of the piston, and on account of the difference between the piston area and that of the annular surface of the underside of the piston, the latter is forced outwards. The outward movement continues until the orifice E is again covered by the collar F, when the air is cut off from the upper side of the piston and the outward movement is checked and finally arrested by the re-established air pressure on the annular underface of the piston. The momentum of the piston carries the orifice E past the collar F as shown in Fig. 2, and the compressed air on the upper side of the piston exhausts into the atmosphere and so increases the influence of the air pressure on the annular underface of the piston. Air cushions are thus formed at each end of the piston stroke so that there is no jarring. It will be seen that the degree of cushioning depends on the position of the orifice E and on the thickness of the collar F.

348,002. Sir W. G. Armstrong Whitworth & Co. (Engineers), Ltd., and George C. Stevens, both of Scotswood Works, Newcastle-on-Tyne, patentees. Herbert Haddon & Co., Agents, Grainger Street West, Newcastle-on-Tyne. Accepted, May 7, 1931.

Some Contracts.

Several contracts have recently been received in connection with the building of the large new Cunard liner at Clydebank by John Brown and Co., Ltd. The Wallsend Slipway and Engineering Co. Ltd., Wallsend-on-Tyne, are to supply and fit the liner's oil burners; this is the largest oil-burning equipment for a single vessel which this firm has received and will amount to several thousand pounds. The steering gear is to be supplied by Brown Brothers and Co., Ltd., Edinburgh, who will obtain the variable delivery pumps for the gear from the Variable Speed Gear, Ltd., a subsidiary company of Vickers-Armstrongs, Ltd.

The Westinghouse Brake and Saxby Signal Co., Ltd., Chippenham, Wilts., have received the following two orders:—58 vacuum servo brake sets for the Associated Equipment Co., Ltd., Southall, Middlesex, to be fitted to "Regent" type 'buses; and 10 pressure brake sets for trolley 'buses for Nottingham Corporation.

Marshall, Sons and Co., Ltd., of Gainsborough, have received from the U.S.S.R. an order for 175 portable locomobiles for use in the timber trade. The order, which is valued at nearly £100,000, is to be completed by September of this year.

Leyland Motors, Ltd., Leyland, Lancs., are to supply the Co-operative Wholesale Society, Ltd., Irlam, Lancs., with 10 "Badger" and four "Buffalo" types of their vehicles.

Liverpool Corporation have ordered from Crossley Motors, Ltd., Manchester, one heavy-oil motor omnibus, complete with body and self-changing gear, at a cost of £1,940.

An order has been received by Sir William Arrol and Co., Ltd., Glasgow, for two 7½-ton wharf cranes for the Barking Power Station of the County of London Electric Supply Co.

An order has been received by C. D. Peters and Co., Ltd., Slough, Bucks., from the Gloucester Railway Carriage and Wagon Co., Ltd., for 40 sets of power-operated door equipment, to be fitted to new rolling stock for the London Underground Railways.

With a view to improving the existing Chinese commercial air services and to establishing new air routes, the Chinese Nationalist Government has decided to place a contract with British firms for commercial aircraft. It is understood that this contract includes orders for 12 "Avro" planes from A. V. Roe and Co., Ltd., Newton Heath, Manchester, and 18 Westland "Wapite" from the Westland Aircraft Works, Yeovil, Somerset.

The Pearson and Knowles Engineering Co., Ltd., Warrington, have received two orders from Milliken Brothers, Ltd., of a total value of over £100,000. One is for the manufacture and galvanising of 6,000 tons of transmission towers for the South-West England and South Wales electricity scheme; and the other is for the manufacture and erection of towers for the River Thames crossing, which are the highest self-supporting towers built in this country.

Guy Motors, Ltd., Wolverhampton, have received orders for their 3/4-ton vehicles from:—The London County Council; Shell-Mex, Ltd.; Ever-Ready Co., Ltd.; Redline Motor Spirit Co., Ltd.; and L. E. Taylor and Co., King's Lynn. Among those who have ordered 20-seater, 30-cwt. and 40/50-cwt. vehicles are:—United Automobile Services, Ltd.; the *Evening Standard*; Birmingham Electricity Department; R. E. McLean and Co., Belfast; Palladium Garage, Ltd., Bradford; Wheatley and Whiteley, Leeds; Claud Hamilton, Aberdeen; and the Paragon Motor Co., Hull.

Vickers-Armstrongs, Ltd., have received a contract from Newry Harbour Board for installing new outer gates at the Victoria Docks, at a cost of £6,968.

Metropolitan-Vickers Electrical Co., Ltd., have received orders from the Transport Committee of Salford Corporation for 25 gear wheels and 50 pinion wheels, and from the Great Western Railway Co. for Cosmos gas-filled and vacuum lamps (from the Lamp Sales Department, London, W. 1).

As a result of the British Empire Trade Exhibition at Buenos Aires, the British Weighers and Slicers, Ltd., branch of Sheffield Steel Products, Ltd., Templeborough Works, Sheffield, have received an order from a South American company for 100 patent meat-tendering machines. These machines are designed to separate the meat fibres without losing the natural juices of the meat. The series of knives, which are the main feature of the machines, are to be made of Sheffield stainless steel.

The Moss Gear Co., Ltd., Crown Works, Tyburn, Birmingham, have secured orders for 377 worm-reducing gears from an industrial concern in this country, and for 42 double-helical reducing gears for a firm abroad.

Messrs. Crossley Brothers, Ltd., Openshaw, Manchester, have secured the following orders:—A five-cylinder 325-b.h.p. Diesel engine for driving an alternator—the Bridport Electricity Works, Dorset; a three-cylinder engine for the Dinmoer Park Quarries, Beaumaris, Anglesey—Messrs. the Minerals Construction Co., Ltd.; and a three-cylinder unit for electric-generator drive at the Government boot factory at Carlow, Irish Free State.

Richard Dunston, Ltd., of Thorne, near Doncaster, have received an order for a large motor-barge for general cargo service on the Rivers Humber and Trent.

The Dublin Port and Docks Board have placed an order with the Vaughan Crane Co., Ltd., of Openshaw, Manchester, for three overhead electric cranes for use in their tobacco warehouses.

Ruston and Hornsby, Ltd., have received an order from the Ashford Urban District Council for a six-cylinder, 1,200-b.h.p. Ruston vertical oil engine, supercharged, for an extension to the Council's power-station.

The Clarkson Thimble Tube Boiler Co., Ltd., have secured contracts from Harland and Wolff, Ltd., for two boilers for the main engines of the M.V. *Georgic*, and an exhaust-gas and oil-fired boiler for a Nelson liner now being built. The company have also received an order for five silencer boilers for the production of hot water for heating the Bank of England.

The Consolidated Mining and Smelting Co. (of Canada), Ltd., have placed orders with Dunford and Elliott (Sheffield), Ltd., for two rotary louvre furnaces to dry 150 tons of sulphate of ammonia per day.

John Redhead and Sons, Ltd., of South Shields, have secured the contract for the repair of the steamer *Queenmoor*, which was almost destroyed by fire on Christmas Eve off Aden. The *Queenmoor*, which was built by Messrs. Redhead and Sons, is owned by W. Runciman and Co., Ltd., Newcastle and has been in dry dock at West Hartlepool since the beginning of May. The repairs, it is said, will cost something like £40,000.

The Hunslet Engine Co., Ltd., of Leeds, have received from John Mowlem and Co., Ltd., of Westminster, an order for eight locomotives of the 0–6–0 standard industrial type, with 14 in. × 20 in. cylinders. These are for use in connection with the building by Messrs. Mowlem, in conjunction with Edmund Nuttall and Co., Ltd., of Trafford Park, Manchester, of the new Southern Railway graving dock at Southampton.

Siemens' Electric Lamps and Supplies, Ltd., of 38/39, Upper Thames Street, E.C. 4, have received the following orders for electric lamps:—For the supply of all types—the Air Ministry; for 12 months' supply—Electricity Department of the Epsom Urban District Council; for 12 months' supply of gas-filled lamps—Great Western Railway Co.

Commer Cars, Ltd., Luton, Beds., have received an order from the Electricity Department of the Bath Corporation for a C 2-type 40/50-cwt. chassis, mounting a mechanical three-way tipping lorry body.

The Whessoe Foundry and Engineering Co., of Darlington, have received an order for the construction of several tanks for the Shell-Mex Co. About 1,000 tons of steel will be required to make the tanks.

Aluminium as an Architectural Metal.

THE extraordinary rapidity with which the light alloys have gained popularity in the United States as architectural materials is shown by the number of recently constructed important buildings in the decoration of which the new materials play a large part. The Chrysler Building, which was the largest building to make this departure from established practice, has now been eclipsed in height by another New York skyscraper, the Empire State Building at the corner of Fifth Avenue. It is claimed that this structure, which is just being completed, affords an even more remarkable example of the application of aluminium to architecture than the Chrysler Building. On the roof above the eighty-odd storeys of the building there is being constructed a steel tower, over two hundred feet high, and intended as an observation tower and airship mooring mast. The top of this tower is 1,248 feet above ground level, and the whole is being given a striking appearance by sheathing with aluminium alloy. About 150 tons of castings and extruded shapes in a silicon (5%) alloy are being used for this purpose. Besides covering the entire tower, except for alloy steel strips between the windows, this light alloy is also being employed in a stairway leading into the tower, in large wings built up of castings at the corners, and for the window casements and sashes, these being highly polished to contrast with the frosted finish of the rest. To obtain the desired colour for the aluminium alloy covering the tower, the pieces, some of which are 5 ft. by 8 ft. and even larger, are individually sand-blasted by means of special apparatus, medium-grain sea sand being used to provide a fine-grained frosted finish. This treatment is followed by hand spraying with a special preparation to retain the colour obtained. Altogether about 380 tons of light metal are being embodied in the Empire State Building, in the form of store fronts, marquises, lift-doors, observation tower, and 5,704 spandrels. The latter are anodically treated to give a dark grey finish, and are set in vertical lines beneath the windows, separated from the vertical lines of white stonework by strips of polished stainless steel.

This movement towards the adoption of aluminium as an architectural metal, although hitherto practically confined to the United States, now shows signs of spreading thence to Canada and Europe. Thus, a notable feature of the new building of T. Eaton & Co., in Toronto, is the use of light alloy castings for the cresting details, while case aluminium spandrels are used on the Office Speciality Manufacturing Co.'s building in Montreal: interest in the wide possibilities of the new medium is now being aroused in British and Continental architectural circles as well. The perfecting of various processes, notably anodic oxidation ones, to enable light metals to be provided with various finishes and colourings, together with the development of light alloy structural pieces, will soon provide the architect with commercial products in aluminium which will give him still greater scope in his designs and enable him to use the light, rustless metal for further numerous purposes for which this easily worked and handled and essentially modern material is particularly suited.

New Factory Regulations for Chromium Plating.

Under the Factory and Workshop Act, 1901, the Home Secretary has made regulations, to come into force on August 1 next, covering the chromium-plating trade.

The regulations lay down that it is the duty of employers to provide an efficient exhaust draught to prevent vapour or spray entering workrooms. Employees must be provided with aprons and bibs, rubber gloves, rubber boots or other waterproof footwear, and have suitable washing and clothes storage accommodation. An adequate supply of wholesome drinking-water must also be provided.

Employees must be examined by a surgeon every 14 days. No one under the age of 18 may work at a bath.

The employer must arrrange for inspection of the hands and forearms of all employees by a responsible person twice a week.

Iron and Steel.

THE difficulties which have for so long confronted the iron and steel trades, both on the production and consumption sides, seem to increase rather than diminish, and the much reduced output compared with a year ago is eloquent of the present position.

Many of the causes of the depression are world-wide, and altogether beyond the control of the British iron and steel industries. On the other hand, much of the idle plant in this country is attributed by them to the supplies of cheap foreign materials, principally Continental, which are offered in the home markets. The National Federation of Iron and Steel Manufacturers has followed up recent statements on the matter by a further call for some measure of protection in the home markets.

The unrest among steel users, who are parties to the British rebate scheme, has been voiced during the past few weeks by the Central Board of the Shipbuilding Employers' Federation, who resolved to renew their representations to the British steel makers on the necessity for an early reduction in British steel prices. It is urged that the wide difference between the prices of British and Continental steel materials constitutes a great handicap to British shipbuilders in their competition with foreign firms, who are said to be obtaining much of the restricted amount of new orders available as a result of their ability to quote on the basis of cheap foreign steel.

Price developments in the heavy-steel industry will be watched with interest by all other steel users, particularly constructional engineers. Forward contract buying of any magnitude is virtually at a standstill, and users generally are awaiting the decision which the Steel Producers' Association must make at its next meeting.

In the meantime, business in almost every branch of the iron and steel trade is disappointingly slow. Some of the principal foundry-iron producers are fortunate enough to be able to dispose of a portion of their make in associated undertakings, but they are finding outside outlets difficult to obtain. One factor whose influence has grown in intensity during the past month or two has been the huge tonnage of cheap machinery scrap, especially in Lancashire, where textile and other plant has been broken up and offered to iron founders at little more than half the price of pig iron. These offers have been readily taken up, and a marked reduction in the demand for foundry iron has been experienced in consequence.

Midland producers have lowered selling prices in the hope of attracting more business, and they were quickly followed by north-east coast makers, but up to the present no perceptible improvement has been reported. Finished-iron prices have also been substantially reduced, but here again without noticeable effect on the demand.

Steel rollers have been suffering from a dearth of important orders for shipbuilding and structural materials, the bulk of the orders that are being placed covering only early needs.

In special alloy steels a moderate weight of business in the aggregate is being done, principally in connection with motor-car and aviation work. As already indicated, users are hoping for lower prices for the controlled materials. In the products that are not subject to control the price tendency of late has been in a downward direction, and somewhat lower rates are being indicated in respect of acid and basic boiler plates and re-rolled bars.

Slight Expansion in May Output.

Production of pig-iron amounted 346,500 tons, compared with 323,200 tons in April and 614,500 tons in May, 1930. The production includes 88,900 tons of hematite, 122,400 tons of basic, 107,100 tons of foundry and 14,300 tons of forge pig-iron.

The May output of steel ingots end castings amounted to 435,100 tons, compared with 397,400 tons in April and 691,900 tons in May, 1930.

MARKET PRICES

ALUMINIUM.

99% Purity	£85	0	0

ANTIMONY.

English	£35	0	0
Chinese	22	10	0
Crude	19	0	0

BRASS.

Solid Drawn Tubes	lb.	9¼d.
Brazed Tubes	lb.	11¼d.
Rods Drawn	,,	8¾d.
Wire	,,	7¾d.
*Extruded Brass Bars	,,	4¾d.

COPPER.

Standard Cash	£35	3	9
Electrolytic	38	0	0
Best Selected	36	5	0
Tough	35	15	0
Sheets	70	0	0
Wire Bars	39	7	6
Ingot Bars	39	7	6
Solid Drawn Tubes	lb.		10¼d.
Brazed Tubes	,,		10¼d.

FERRO ALLOYS.

‡Tungsten Metal Powder	lb.	0	1	11½
‡Ferro Tungsten	,,	0	1	8½
§ Ferro Chrome, 60-70% Chr. Basis 60% Chr. 2-ton lots or up.				
2-4% Carbon, scale 11/- per unit	ton	28	0	0
4-6% Carbon, scale 7/- per unit	,,	21	10	0
6-8% Carbon, scale 7/- per unit	,,	20	12	6
8-10% Carbon, scale 7/- per unit	,,	20	0	0
§ Ferro Chrome, Specially Refined, broken in small pieces for Crucible Steel-work. Quantities of 1 ton or over. Basis 60% Ch. Guar. max. 2% Carbon, scale 10/- per unit	,,	:0	10	0
Guar. max. 1% Carbon, scale 13/6 per unit	,,	:4	7	6
§Guar. max. 0.7% Carbon, scale 15/- per unit	,,	57	17	6
‡Manganese Metal 96-98% Mn.	lb.	0	1	3
‡Metallic Chromium	,,	0	2	7
§ Ferro-Vanadium 25-50%	,,	0	12	8
§ Spiegel, 18-20%	ton	6	17	6
Ferro Silicon—				
Basis 10%, scale 3/- per unit	ton	5	17	6
20/30% basis 25%, scale 3/- per unit	,,	7	0	0
45/50% basis 45%, scale 5/- per unit	,,	9	17	6
70/80% basis 75%, scale 7/- per unit	,,	16	5	0
90/95% basis 90%, scale 10/- per unit	,,	24	17	6
§ Silico Manganese 65/75% Mn., basis 65% Mn.	,,	13	12	6
§ Ferro-Carbon Titanium, 15/18% Ti	lb.	0	0	6
Ferro Phosphorus, 20-25%	ton	15	1[illegible]	0

FUELS.

Foundry Coke—				
S. Wales Export	£1 2 0 to	£1	16	6
Sheffield Export	0 14 0 to	0	15	0
Durham Export		1	4	0
Furnace Coke—				
Sheffield Export	0 14 0 to	0	15	0
S. Wales ,,	0 16 6 to	0	17	6
Durham		0	13	0

GUN METAL.

*Admiralty Gunmetal Ingots (88 : 10 : 2)	£52	0	0
*Commercial Ingots	42	10	0
*Gunmetal Bars, Tank brand, 1 in. dia. and upwards.. lb.	0	0	10
*Cored Bars ,,	0	1	0

LEAD.

Soft Foreign	£11	6	3
English	12	15	0

MANUFACTURED IRON.

Scotland—			
Crown Bars	£10	5	0
N.E. Coast—			
Rivets	11	5	0
Best Bars	11	0	0
Common Bars	10	10	0
Lancashire—			
Crown Bars	9	15	0
Hoops	12	5	0
Midlands—			
Crown Bars.... £9 10 0 to	10	7	6
Marked Bars	12	0	0
Unmarked Bars		—	
Nut and Bolt Bars........ £8 10 0 to	9	0	0
Gas Strip	10	17	6
S. Yorks.—			
Best Bars	10	15	0
Hoops	12	0	0

PHOSPHOR BRONZE.

*Bars, "Tank" brand, 1 in. dia. and upwards	lb.	10d.
*Cored Bars	,,	1/-
†Strip	,,	11⅛d.
†Sheet to 10 W.G.	,,	11¾d.
†Wire	,,	1/0
†Rods	,,	11¼d.
†Tubes	,,	1/4¼
†Castings	,,	1/1

†10% Phos. Cop. £30 above B.S.
†15% Phos. Cop. £35 above B.S.
†Phos. Tin (5%) £30 above English Ingots.

PIG IRON.

Scotland—			
Hematite M/Nos.	£3	10	0
Foundry No. 1	3	13	6
,, No. 3	3	11	6
N.E. Coast—			
Hematite No. 1	3	4	6
Foundry No. 1	3	1	0
,, No. 3	2	18	6
,, No. 4	2	17	6
Cleveland—			
Foundry No. 3	2	18	6
,, No. 4	2	17	6
Silicon Iron	3	1	0
Forge No. 4	2	17	0
N.W. Coast—			
Hematite	4	4	6
Midlands—			
N. Staffs Forge No. 4	3	1	0
,, Foundry No. 3	3	6	0
Northants—			
Forge No. 4	2	17	6
Foundry No. 3	3	2	6
Derbyshire Forge	3	1	0
,, Foundry No. 3	3	6	0
West Coast Hematite	4	2	6
East ,, ,,	4	0	0

SWEDISH CHARCOAL IRON AND STEEL.

Pig Iron	£6 0 0 to	£7 10 0
Bars, hammered, basis	£17 10 0 ,,	£18 10 0
Blooms	£10 0 0 ,,	£12 0 0
Keg steel	£32 0 0 ,,	£33 0 0
Faggot steel	£20 0 0 ,,	£24 0 0

All per English ton, f.o.b. Gothenburg.

SCRAP METAL.

Copper Clean	£26	0	0
,, Braziery	2[illegible]	0	0
,, Wire		—	
Brass	18	0	0
Gun Metal	25	0	0
Zinc	3	15	0
Aluminium Cuttings	46	0	0
Lead	8	5	0
Heavy Steel—			
S. Wales ......£2 2 6 to	2	5	0
Scotland ......£1 17 6 to	2	0	0
Cleveland	2	0	0
Cast Iron—			
Lancashire	2	5	0
S. Wales........£2 5 0 to	2	6	0
Cleveland ....£2 4 0 to	2	5	6
Steel Turnings—			
Cleveland	1	7	0
Lancashire	1	0	0
Cast Iron Borings—			
Cleveland	1	4	0
Scotland	1	10	0

SPELTER.

G.O.B. Official		—	
Hard	£7	5	0
English	10	15	0
India	10	0	0
Re-melted	9	10	0

STEEL.

Ship, Bridge, and Tank Plates—			
Scotland	£8	15	0
North-East Coast	8	15	0
Midlands	8	17	6
Boiler Plates (Land), Scotland..	10	10	0
,, ,, (Marine) ,, ..	10	10	0
,, ,, (Land), N.E. Coast	10	0	0
,, ,, (Marine) ,,	10	10	0
Angles, Scotland	8	7	6
,, North-East Coast	8	7	6
,, Midlands	8	7	6
Joists	8	15	0
Heavy Rails	8	10	0
Fishplates	12	0	0
Light Rails	8	15	0
Sheffield—			
Siemens Acid Billets	9	10	0
Hard Basic .. £8 2 6 and	8	12	6
Medium Basic	7	2	6
Soft Basic ......£6 0 0 to	6	5	0
Hoops ....£9 10 0 to	9	15	0
Manchester—			
Hoops	9	15	0
Scotland, Sheets 20 W.G.	9	10	0

HIGH SPEED TOOL STEEL.

Finished Bars 18% Tungsten.	lb.	2/9
Extras		—
Round and Squares, ½ in. to ¼ in.	,,	3d.
Under ¼in. to 3/16 in.	,,	1/-
Round and Squares 3 in.	,,	4d.
Flats under 1 in. × ⅛ in.	,,	3d.
,, ,, ½ in. × ¼ in.	,,	1/-

TIN.

Standard Cash	£103	2	6
English	104	5	0
Australian	104	0	0
Eastern	105	10	0
Tin Plates I.C. 20 × 14 box	14/- to 14/3		
Block Tin Cash	£100	15	0

ZINC.

English Sheets	£20	0	0
Rods	20	10	0
Battery Plates	14	10	0

* McKechnie Brothers, Ltd., quoted June 9. † C. Clifford & Son, Ltd., quoted June 9. ‡Murex Limited, quoted June 9.

Subject to Market fluctuations, Buyers are advised to send inquiries for current prices.

Lancashire Steel Corporation's Current Basis Prices, f.o.b. Liverpool or Stations in Lancashire :—Wrought Iron Bars, £9 15s. 0d.; Mild Steel Bars, £6 15s. 0d.; Wrought Iron Hoops, £12; Best Special Steel Baling Hoops, £8 10s. 0d.; Soft Steel Hoops (Coopers' and Ordinary Qualities), £8 0s. 0d.; C. R. & C. A. Steel Hoops, £11 10s. 0d. to £12 0s. 0d; "Iris" Bars, £8 5s. 0d. All Nett Cash. Quoted June 9. § Prices quoted June 9, ex warehouse.